TITLE: **ELECTROSTATIC PRINTING OF FUNCTIONAL TONER MATERIALS FOR ELECTRONIC MANUFACTURING APPLICATIONS**

Inventor: Robert H. Detig

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the priority of U.S. Provisional Patent Application Serial No. 60/104,079 filed October 13, 1998, the entire contents and subject matter of which is hereby incorporated in total by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The invention concerns a process for the electrostatic printing of functional materials configured as liquid toners on relatively thick glass plates for various manufacturing applications.

2. Description of the related art.

Flat panel displays or wall type television sets have been discussed in the prior art literature for about forty years, but few have been produced. As of mid 1998 there were three primary flat panel technologies for flat panel displays:

a. Field Emission Displays (FED's.)

b. Plasma Displays

c. Active Matrix Liquid Crystal Displays (AMLCD)

Field emission displays are a relatively new technology. They consist of an array of field emission points in a vacuum, spraying electrons onto a phosphor screen. With three color dots on the screen and addressibility of the emitting points, one has a full color display.

The Plasma displays have been produced for about 25 years, mostly as a single color orange neon "glow discharge". In the last 10 years, UV light from this discharge has been

"harnessed" to excite three color phosphors to produce a color plasma displays. 40" diagonal displays have been recently announced, but their cost is about $10,000.

Active matrix liquid crystal displays have been intensively developed for production. Billions of dollars have been spent on their development over the last 20 years, but the results have been only an expensive small display (10.4 inch diagonal) for lap top computers. The 1996 cost of a 10.4" display is about $500. Wall type TV units, 20" diagonal or so, are perhaps available after the year 2000, but very expensive.

The reason for the small size/high cost of production are the currently used manufacturing techniques. These include:

a. photolithography or the patterning of photo sensitive resists and the "washing" and etching processes that are attendant to them.

b. the silk screen printing of relatively large area features (30μ or more)

c. the low pressure sputtering processes for coating glasses with metals like aluminum or indium / tin oxide (ITO), a transparent electrode or dielectrics like SiO_2.

In all cases the process has many steps, many in which the glass has to be heated and then cooled back to room temperature before the next step. Each of these steps requires a large piece of capital equipment in a class 100 clean room whose capital cost is $500 per square foot for the room itself. The capital equipment runs the gamut from a $40,000 liquid etcher, or developer, to a $2.5M stepper to a $4M sputtering cluster (six to eight vacuum chambers that accept 1m x 1m glass).

There is "suite" of expensive capital equipment in a typical $500 per square foot clean room so that the cost of a modern AMLCD production facility is approximately $500 Million. None of the raw materials for the displays, including the glass, glass powder or frit,

phosphor, aluminum or nickel, resin or color filter resins are very expensive. Costs are incurred by the capital equipment and low yield of a complex process with many steps.

What is needed is a simpler manufacturing process with fewer steps that requires less capital equipment, does not involve heating and cooling within the imaging step as this dimensionally distorts the glass substrate by thermal expansion, and is implementable with relatively inexpensive machinery, i.e. no vacuum chambers, laser exposure steps etc.

Electrostatic printing has been used for color proofing in Du Ponts EMP process during the late 1980's. Du Pont used the electrostatic printing which is described by Reisenfield in US No. 4,732,831. It used liquid toners that were transferred directly to a smooth, coated sheet of paper.

The transfer of liquid toner, which is important to this invention, was disclosed by Bujese in US No. 4,879,184 and US No. 4,786,576. These documents teach the transfer of liquid toners across a finite mechanical gap, typically 50μ to 150μ. This technology has been applied where toner, with etch resist properties, was transferred to copper clad glass epoxy boards.

Other prior work related to the printing plate and "gap transfer" includes M.B. Culhane (Defensive Publication# T869004, Dec 16, 1969) and Ingersol and Beckmore to the electrostatic printing plate (US No. 3,286,025 and RE 29,357; RE 29,537 respectively).

SUMMARY OF THE INVENTION

Briefly described, the present invention teaches a technique for the electrostatic printing of functional materials on glass to produce various "microstructures" like ribs or electrodes, spacers, filters etc. by a copy machine type of device at rates from 0.1 to 1.0 m/sec. In some cases there is a later step of sintering or electroless plating, but this is "after the fact" in that dimensional accuracy was previously determined by the printing step done at room temperature. The functional materials include metals, dielectrics, phosphors, catalytic

seed materials, etc. configured as liquid toners. Since the substrate material is glass it presents special requirements:

1. It is mechanically of irregular shape (i.e. it is wedge shaped in orthogonal directions and its thickness has considerable variation); and,

2. It is a very thick material to be electrostatically imaged compared to the paper or polymeric films printed on by copiers or laser printers.

For this reason the invention uses liquid toners (dispersions of solid particles; metal, glass, etc.) that can be electrostatically transferred across a significant mechanical fluid filled gap.

While the "gap transfer" technique just described is useful in production machinery handling 1.0m by 1.4m plates, there are many situations where the printing capability on a relieved surfaced is a significant advantage, and the magnitude of surface relief can be quite substantial, of the order of 0.1mm or 100μ or more.

The electrostatic printing function is typically done in one process step. Afterwards the particulate mass is fused into a solid structure with a subsequent heating step. In one embodiment of the invention, catalytic seed toners are printed followed by "electroless" plating steps where metals like copper, or nickel, are deposited on the glass.

Finally, there are certain partially manufactured products like color filters or CRT face plates which can be used in a process wherein the final part plays the role of a printing plate to print on itself. This is very simple and therefore inexpensive process which contains a "self-healing" feature. Imperfections in the semi finished parts are automatically overprinted with the liquid toner.

The invention may be more fully understood by referring to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates an overall mechanical schematic of the invention.

Fig. 2 illustrates a detailed view of the nip between drum and glass.

Figs. 3a-d illustrate the electrostatic printing plate and the four steps in the imaging process.

Figs. 4a-c illustrate the progressive exposure of the electrostatic printing plate.

Fig. 4d illustrates a plate exposed one quarter of its thickness.

Figs. 5a-b illustrates the ideal and typical charge decay cures for the electrostatic printing plate.

Figs. 6a-d illustrates the four typical corona devices used in copy machine and electrostatic printers.

Figs. 7a-b illustrates the printing plate current versus voltage for smooth wire and pin array corona units respectively.

Figs. 8a-b illustrates the printing plate current versus the voltage on the plate for dicorotrons and scorotons respectively.

Fig. 9 illustrates the plate/glass layout with its equivalent circuit.

Figs. 10a-b illustrate electrical changes induced in printing plate during the transfer step.

Fig. 11 illustrates a mechanical schematic of a "flat" to "flat" printing apparatus.

Fig. 12 illustrates a crossection of a typical AC plasma display panel.

Figs. 13a-c illustrate detailed sequences of manufacturing steps in the production of critical features of the AC plasma display.

Fig. 14a-c illustrates the "self-printing" of the black intermatrix of a color filter panel

Fig. 14d illustrates the self-printing of a vacuum phosphor front panel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

During the course of this description, like numbers will be used to identify like elements according to the different views which illustrate the invention.

Fig. 1 shows an overall mechanical schematic of the preferred embodiment. Drum 10 has a latent electrostatic image 13 on its surface 11. It is charged by sensitizing corona 12. If it is a photo sensitive surface it is exposed in an image wise fashion by LED/ strip lens assembly 14. Alternately it could compose an electrostatic printing plate as disclosed by Reisenfeld of US No. 4,732,831 where the image areas retain charge and the background areas discharge before the drum 10 rotates to the developer unit 16. The unit 16 is comprised of toner developer roller 18 that are splashed with liquid toner by pipe 20. They rotate in such a manner as to move in the same direction of the drum but typically at a relative velocity of 1.5 times. Reverse roller 22 rotates in a manner opposite the drum 10 and with a relative velocity of 3 times. The purpose of this reverse roller 22 is to scavenge excess toner liquid off the image surface 11 which also controls unwanted background. A corona unit 24 at roughly the 5 o'clock position serves to "compact" the toner image before transfer. This is also referred to as "depress" corona.

Glass plate 26, which is pre-wetted with toner diluent, moves from right to left. It rests on insulating rollers 28 which are spaced with respect to the drum surface 11 to provide a nominal gap 42 between the glass surface 26 and the drum surface 11. Means are used to "float" either the image drum 10 with respect to the glass surface 26 or the glass surface 26 with respect to the drum 10, or glass 26, these are well known to those skilled in the mechanical arts. Corona unit 30 charges the bottom surfaces of the glass 26. Wire 31 is raised to about 7 kilovolts grounded mechanical shutters 32 are adjustable to charge the glass 26 at the proper desired location to achieve optimum toner transfer. Corona unit 34 is an AC corona discharge to discharge the drum 10 before cleaning. Alternately this unit, or a second AC corona, may be located after cleaning unit 36. This first AC corona is not shown.

Cleaning unit 36 typically consists of a squeegee roller 38 that does bulk, rough removal of residual toner, while wiper blade 40 does the final, complete cleaning of the drum surface 11. The drum 10 is now ready for the next image.

Important details of this embodiment are revealed by Fig. 2. Here is shown an enlarged view of the drum 10, gap 42, glass structure 26 at the transfer point, nominally at 6 o'clock. The drum 10 is wet with liquid toner and residual diluent coming into the nip formed by drum 10 and glass 26. The glass is pre-wetted with clear diluent to ensure that the gap between drum and glass is filled with liquid. Metering of liquid on the drum and the pre-wetting liquid on the glass is not very precise so a wave of excessive liquid 44 builds up in the input to the nip. This is referred to, herein, as the Tsunami effect. The toner on the drum before transfer 50 needs to transfer to the glass in a location of low turbulence, about 6 o'clock.

Alternately on the output end, the amount of liquid between drum and glass is precisely determined by the gap which is between 50μ to 150μ and can be easily controlled to +/- 5μ with the "floating" techniques mentioned previously. Therefore a "film splitting" occurred as shown in Figure 2 not necessarily 50%/50% as suggested by this drawing. Actual values will depend on the surface energy of the drum surface (amorphous selenium or silicon or alternately a photopolymer) versus that of the glass. For the purposes of this invention the film splitting point 46 is precisely defined and unchanging for particular materials and one gap setting while the wave front 44 is highly unstable and moves to the right from the beginning of the glass sheet to its end and can become quite violent and turbulent.

Important features of the preferred embodiment are now evident:

First: the actual transfer electric fields can be quite large as typical soda lime glass has substantial electrical conductivity (as much as 10^{-10} mho/cm) so the corona

charge migrates through the glass to near the transfer point. As the drum and glass surface start moving away for each other very high electric fields can be generated.

Second: By moving the location of the corona and the shutters laterally, the exact location of the transfer "zone" can be moved with respect to the wave 44 and exit film splitting point 46. US No. 4,849,784 by Blanchet-Fincher teaches the importance of not attempting gap transfer in the turbulence of the input wave.

Third: After transfer toner particles 48 are tightly bound to the surface of the glass by the internal transfer charges from the transfer corona. This prevents them from being smeared by random motion of residual diluent liquids on the glass before the toner is dried. Alternately if toner is transferred to a metal surface it is held to that surface by its "image" charge "seen" in the metal. This is classical electrostatic theory. Typically these "image" forces are significantly smaller than the strong binding forces between surface toner and the nearby transfer charges.

Other important features of this invention are the ability to print very large substrates, one meter by one meter or more with very small "features" (i.e. the dimensions of the image elements) and with very high levels of "overlay" accuracy (i.e. the registration of features) on one layer (or printing step) to overlay accurately the features on subsequent layers (or printing steps).

The electrostatic printing plate is shown in Fig. 3a is a photopolymer layer 52 bonded to an electrically grounded substrate 54. A photopolymer layer 54 is heat and pressure laminated to a grounded substrate, typically an aluminized polyester film (PET). It is then exposed through a contact photo tool to actinic radiation (350nm to 440nm wavelength) to cross link the exposed areas. In Fig. 3b the plate is charged by a corona unit 56. The cross

linked areas are much higher in electrical resistivity than normal photopolymer so they store charge for significant periods of time. After a suitable delay to allow the normal photopolymer to discharge, we have a latent image on the printing plate as in Fig. 3c. In Fig. 3d a "reversal" development is effected with a liquid toner 58, i.e. development of the discharged areas of the plate (those referred to as normal photopolymer or not cross linked). Note the process can be a “normal” image, where the charged areas are developed or reversed as previously mentioned.

The Electrostatic Printing Plate can be film coated from a liquid solution which can be dried and partially hardened by a gentle bake. Coating methods include roller coating, spray coating, spin coating, dip coating or meniscus coating. Useful liquid photopolymers are usually negatively acting ones, those that cross link and that are insoluble in hydrocarbons or at least not significantly swelled by them. Typical examples of commercially available liquid materials are: Hoechst AZ-5200 IR, and MacDermid HDI-1, 2 or 3, also Mac Dermid. MT-1400. The dry film photopolymers are precast films than can be heat and pressure laminated to suitable substrates. They include these materials:

DynaChem®	AX 1.0 or 1.5 UF 0.5 or 1.0 5032, 5038, 5050
MacDermid®	SF- 206 CF-1.3
DuPont Riston®	9512 4615

The liquid resists can range in thickness from a fraction of a micron to about 15μ to 20μ depending on the coating technique used. They are typically in the fractional to 15μ range. The dry film resists tend to be much thicker in the 13μ to 50μ range; the ones of greatest interest here are 25μ to 38μ thick. But one requirement in flat panel manufacture is the generation of ever smaller features, in the 10μ to 5μ range. This presents some difficulty

with resists in the 30μ to 50μ range; in the 30μ to 50μ range; less of a problem in the 5μ to 10μ range.

An important feature of this invention is the partial exposure of the photo resist. Data has shown that the photopolymer 52 is exposed in ever increasing thickness of a layer starting at its surface, as shown in Fig. 4a through 4c. Increasingly by longer exposure to actinic radiation 60 cross-links ever deeper layer of the photo polymer. Therefore if one is using photopolymer at 38 micron thick but wants to make 5μ features, one might expose only one quarter of it in thickness as shown in Fig. 4b. One now has highly resistive image in a "sea" of less resistive background areas. Since we never remove the unexposed background areas (an indeed their presence is a critical element in the success of the process, as discussed next), the partially exposed (or unexposed layers under the image) present no problems. One determines the proper level of exposure for the "partial exposure" condition by a series of increasing exposure levels and measuring the charge voltage in large solid areas.

A second important feature of this invention is the need to keep the initial charge voltage on the exposed and unexposed regions to be either equal or with in 50% of each other (i.e. V unexposed = 0.5 V exposed). The reasons for this are subtle ,but crucial, for the success of the process. Fig. 5a shows the ideal charge decay curves for the image elements 66 (V exposed = f(t)) and the background regions 68. (V unexposed = f (t)). Note after a short period of time there is no voltage in the background regions while the voltage and the image elements has decayed very little. While this is ideal and theoretically achievable in practice the initial charge voltage in the unexposed regions of the plate should be 50% or more of those values for the exposed regions as shown in Fig. 5b, exposed 70 and unexposed 72. The reason for this is a phenomenon called the "island effect". Basically a small spot of a good dielectric like PET setting on a "sea" of bare copper cannot be charged to any significant value because of the electric field lines from the "island" to its surrounding "sea"

which is at zero or grounded potential. These “field lines” direct incoming electric charge away from the image element and they land on the background areas.

Some photopolymers in the unexposed condition turn out to be “too” conductive and will not charge up to any significant value under the corona charge. Such plates when imaged by simple conditions will develop out the large image features but small image detail or fine structures are lost.

Such photopolymers can be used if one gives them a broad pre-exposed of the unexposed plate to bring it up to the proper electrical resistivity so that the initial voltage in the background areas is adequate. Then the pre-exposed plate is imaged with a photo-tool to produce a proper image above the pre-exposed level. This has been done is silver halide for years and is called “pre-fogging” of the plate. Pre-exposure of an electrostatic printing plate is discussed in prior art literature such as Bujese in US No. 4,968,570.

Other photopolymers have just the proper level of resistivity in the unexposed regions and require no pre-exposure or “pre-fogging”. Some materials easily pick up moisture from the air and their intrinsic or unexposed resistivity depends upon their storage history and packaging. Generally these effects are not troublesome once known by the user and proper modern packaging and careful storage can yield a well defined photopolymer plate. Bench mark testing of each batch of photopolymer will easily yield data to define proper exposure and “pre-fog” exposure if needed.

A third aspect of an optimized electrostatic printing process is the design and “type” of corona unit use as the charge corona. The machine design shown in the invention includes an AC erase discharge corona located just in front of the charge or sensitizing corona. By careful attention to design the AC corona will “reset” or discharge all areas of the plate after the last print cycle. Now the plate is ready to be charged. Ideally the charging cornea will

charge all areas of the plate to the same voltage whether they be large solid areas of image, large areas of background (the unexposed regions) and the fine image structure.

There are basically four different structures used to make corona units in copiers and printers:

1. The familiar bare wire in a metallic shroud.
2. The unit "a" with an electrically biased metal screen or grid between it and the plate or drum (the Xerox trademark for this is a scorotron).
3. The glass coated wire driven by an AC signal in a "U" shaped shroud that has a DC bias, the dicorotron).
4. An etched metal "saw tooth" structure of corona emitting points.

The above approaches have different voltage versus corona current densities that will show which one is optimum for this situation. The electrostatic printing plate poses new problems for corona design. The plate has areas of two different electrical resistivities, the high resistivity charge retaining layer and the lower resistivity background regions. It has already been discussed how a plate could be pre-fogged to raise the background area resistivity to a point where its charge voltage would decay to a negligible value (typically 10% of the initial voltage) within the process time between charging and development. Given that this has been accomplished, the initial charge voltage in the non-exposed or background areas are a fraction of the initial voltage in the exposed areas can be maximized by the choice of charge corona type and its design details. Procedures to accomplish this will now be described.

The various corona devices in use are shown in Fig. 6. The top figure shows the oldest design dating to the late 1950's, the corona unit 74 or a bare wire usually gold plated tungsten of 50μ to 75μ in diameter in a grounded metal shroud. In some designs the front aperture was constricted inward to serve as a self extinguishing function in that the surface to

be charged would not exceed a certain value. This was important otherwise the drum voltage, if excessive, could puncture the photo conductive surface of the drums used at that time, causing permanent damage.

An earlier version of the "pinched" design was the scorotron at the bottom of Fig. 6d. Here a metallic grid 76 structure in front of the corona wire is biased to a voltage perhaps 10% to 25% above the desired surface voltage (typically +800 for a 60μ thick amorphous selenium layer).

The cost of the 1000 volt power supply to bias the grid structure and the assembly costs of the scorotron versus the corotron were the reason for the design of the "pinched-in" Corotron of Fig. 6a.

One problem with the simple corona unit is that in the negative mode the corona discharge is not positionally stable but moves back and forth randomly. One "fix" for this is to super-impress on the DC voltage to the corona wire, typically a ripple value of 10% to 20% of the DC. This caused the high intensity nodes of negative corona discharge to move down the wire at the AC frequency (usually 50 or 60 Hz). This simple, low cost solution was adequate for low speed copiers or printers, but when higher speed units were being designed, a new corona structure, the dicorotron 18 was invented, see Fig. 6c. This used a glass coated wire which was driven by an ac voltage. The shroud (or shield) was biased to a DC voltage which would define whether positive or negative charge was extracted by the corona unit. This design has the advantages of a large diameter glass coated wires that was not easily "fouled" with random dust or toner particles. The bias power supply for the shield was also a low cost design. One unfortunate aspect of this design was that the dicorotron corona unit produced considerable levels of ozone. This trace gas is becoming unacceptable in the office environment.

That situation led to the design of the "pin corotron" 80 or a saw tooth edge 82 that is driven to a high voltage. With a properly made "saw tooth" the corona unit produced very uniform corona discharges, especially negative discharges. This corona unit has been highly successful in recent Xerox® organic photoreceptor machines. The important performance characteristics of a corona unit is the current to the plate to be charged versus the voltage to which the plate has charged. Figs. 7 and 8 show these curves. Note that the wire and pin corotron have the same V-i curves Fig. 7a but that the AC curve Fig. 7b is quite different from the DC curve.

This invention uses an ac neutralizing corona unit to discharge the printing plate at the end of the printing cycle. Either the bare wire or pin corona are adequate for this job. The charging corona is located just after the neutralizing corona. Here a V-i curve is desired that will best charge the exposed and unexposed regions of the printing plate to the same voltage.

The ideal voltage- current characteristic from the corona unit would be one in which the corona current density (in microamps/cm^2) would be independent of printing plate voltage, or a flat straight line in Fig. 7 and 8. Then if the plate is charged quickly, both exposed and unexposed plate areas would charge to the same value, after a suitable delay the unexposed regions would decay to a negligible value yielding an excellent electrostatic "contrast" (the difference between image and background).

Therefore, the best corotron design for this invention is the DC bare wire or pin corotron whose V-i curve is shown on Fig. 7a. It's V-i curves are the "flattest" of the four types of corona units and will yield the high ratio of unexposed to exposed initial charge voltage.

DETAILS OF THE TRANSFER PROCESS

An important part of the invention relates to details of the transfer process not usually encountered in typical transfer processes to film and paper in the copying and laser printing

industries. There toner, either liquid or dry is transferred to relatively thin webs of paper or polymeric film, typically 75 to 100 micron and in all cases the web is in virtual contact with the image surface.

In the invention toner images are transferred to relatively thick layer of glass, 0.5 to 3.0 mm thick (500 to 3,000 micron) spaced away from the image by a fluid filled mechanical gap of 50 to 150 microns. Relative conductivities of the glass versus the gap filling liquid (toner plus added diluent), capacitances, applied voltages and the time over which they are applied etc. are important.

Figure 9 shows a mechanical schematic of the transfer process and a electrical equivalent circuit which allows one to calculate the voltage division across the three elements (glass, gap, and printing plate) during the transfer process.

A. Electrical conductivity of the glass versus the conductivity of the gap liquid

The most critical issues are the conductivities of the liquids in the gap versus the glass as this determines the voltage division between glass and gap. If most of the voltage appears across the glass and very little across the gap between plate and glass, all of toner will transfer. This is best illustrated by some examples:

Printing plate 400 consists of a photopolymer 402 of 10 to 50 micron thickness connected to electrical ground. Receiving glass plate 404 of typical thickness 0.5 to 3.0 mm thickness is backed by a field electrode 406 connected to transfer voltage 408. It is separated by mechanical gap 430 from printing plate 400. The equivalent circuit for this structure 412 is shown to the right.

A-1. A Glass of Interest is Electroviere ELC- 7401 made in Switzerland.

If charged and then the voltage decay measured it shows a decay time constant of 1 second which calculates to a resistivity of $2 \times 10^{+12}$ ohm • cm. Typical ranges of toner bath conductivities are of the order 10 to 100 pico mho/cm (10^{+11} to 10^{+10} $\Omega \bullet$ cm resistivity).

There is one caveatt to be disclosed. The charging test with the glass is a dc test and measures the flow of electronic charges through the glass, while the measure of toner conductivity is an 18 hertz test that measures back and forth flow of electrons, ions, and charged toner particles.

Now applying electromagnetic theory to the glass 404/gap 430 structure initially when a step function of voltage is applied the voltages divide capacities between the elements, glass, gap, and plate. Since the imaged areas of the plate 400 are highly resistive they can be disregarded for short periods of time. Since the glass is thicker than the gap, typically 10 to 100 times, and it's dielectric constant is 5 verses 2.1 of the liquids in the gap, the voltages divided preferentially across the glass with little across the gap. If the conductivity of the gap fluids is higher than the glass this situation will worsen the time and transfer will be inhibited.

With time, the voltages divide resistively between glass and gap. If the conductivity of the gap fluids is higher than that of the glass, practically all of the voltage is across the glass and none across the gap. If toner had transferred, it will back transfer due to the image charges on the printing plate. This, in fact has been observed.

A-2 Conductivity of the Diluent Used to Fill the Gap

Typically when a printing plate is imaged excess toner fluids are very effectively removed by a "reverse roller" that scavenges liquid containing random background particles; the result being a almost dry plate. Now the plate and glass are placed in proximity with each other and the gap between them filled with fluid. If one fills the gap with clear Isopar (conductivity less than 0.15 pmho/cm) the toner charge may be reduced by the lack of charge director is the clear Isopar. If one fills the gap with Isopar plus charge director with a conductivity of 20 pico mho/cm, the voltage division between glass and gap suffers. Again the demands of maintaining charge on the toner particles versus the conductivity of the gap

fluids conflict. Conductive Isopar in the gap is desired but may not be possible if the glass has very high electrical resistivity.

Printing plates 430 and 432 in Figs. 10a and b respectively are "negative" images of each other. 430 is cross linked in the image area and developed with toner 434. 432 is cross - linked in the non-image areas and developed with toner 434. Both plates are sensitized with charges 433. Field plates 436 and driven by voltages 438 and 440 respectively. Receiving glass 442 accepts the transferred image. Mechanical gap 444 is filled with transfer fluid (not shown). High resistivity regions 446 are the cross - linked regions of the plate. Induced charges 448 occur when the transfer voltage is applied and are restricted to the non-cross linked regions of the plate.

B. Mounting Techniques for the Printing Plate and Glass

To preserve the fidelity of the toner image on the plate the transfer electric field must be everywhere normal to the plane of the plate and undistorted on the edges. And since we are transferring to glass with a resistivity of the order of 10^{+12} to 10^{+16} ohm • cm the mounting and holding of the plate must be consistent with these resistivities, i.e. these fixtures must be of materials substantially higher in resistivity. Even with the most conductive glass (lowest resistivity of 10^{+12} ohm • cm) some typical engineering materials, like cotton filled phenolics or poly acetals (Delrin of DuPont) may not be adequate for the job. For instance, Corning 7059 or 1737 glass is typically used for liquid crystal display panels for lap top computers. They have a resistivity of the order of 10^{+16} ohm • cm. A cotton filled phenolic resin material would not be adequate. Teflon™ type materials with resistivities of 10^{+18} are needed.

Also the conductivity of the bath can cause problems around the edges of the printing plate. Since the substrate of the plate is electrical ground, the conductive gap filling liquids might distort the electric fields near the edges of the glass/ plate assembly if they can contact electrical ground causing distorted image transfer.

C. Induced Charges in the Printing Plate During Image Transfer

An important feature of using the fixed resistivity configuration electrostatic printing plate is a phenomenon that helps to "focus" or direct the toner particles during transfer IF the plate is used in the normal imaging mode. By this it is meant that the toner development of the charged areas of the plate as opposed to the "reversal" mode where the discharged areas of the plate are developed with toner particles. The former is used in a typical office copier while the latter is used in a laser or LED printer.

Refer to Figures 10a and b. Figure 10a shows the normal imaging mode, positive sensitizing charges developed with negative toner particles and transferred with a positive electric field. Figure 10b shows reversal with again positive sensitizing charges, positive toner particles transferred with a negative electric field. Note the charge retaining areas of the printing plate, they are highly resistive necessarily to retain the sensitizing charges. The other areas of the plate (areas not cross-linked in the plate exposure step) are much lower in resistivity.

During the transfer step, the transfer field "induces" electrical charges in these lower resistivity areas of the plate, which produces a significant result. Note the charge configuration in the "normal mode" plate, Figure 10a. The sensitizing charges are positive while the induced background area charges are negative. These background area negative charges enhance the strength of the imaging fields and help to control the direction of the toner particles during the transfer step. In the "reversal plate" (Figure 10b), charges induced in the lower resistivity regions of the plate (the non-cross-linked regions) are of the same polarity as the imaging fields and tend to reduce the fields. Indeed if the induced charge density equals that of the sensitizing charges there is no longer an imaging field and toner particles are free to move laterally during the transfer step. This will cause significant "de-

focusing" of the transferred toner image. For this reason, normal imaging is preferred when using the electrostatic printing plate for highest resolution images.

In summary, electrostatic printing process for printing functional materials on glass plates is a simple one with few process step. It has these advantages over current technologies:

1. It is a simple, direct process that proceeds at high rates, to 1 meter/sec.
2. It deposits a wide range of functional materials (conductors, insulators, phosphors, catalyst, etc.) to high definition or resolution with precise positional accuracy (called "overlay" accuracy in the silicon chip industry).
3. It prints on the glass surface without contact which has these advantages:
   a. mechanical tolerances are loosened in the design of production machinery
   b. previously printed materials are not disturbed
   c. it can print on a relief surface. In fact the invention can print a conductive line at the bottom of a 100μ deep trench.
   d. the invention can coat the bottom and walls of the trench with a phosphor material or other applications not yet defined.
4. This is no photolithographic patterning of the glass.
5. There is no mechanical handling of the glass from step to step. We load a clean sheet of glass into the printing device and out comes a finished plate ready for sintering.
6. The process is a room temperature process until sintering so critical to large geometrics due to thermal glass . In the printing of color filters, the four filter colors are printed at room temperature, then baked at once.
7. Expensive functional material is not wasted.

First Alternate Embodiment of the Invention

Fig. 11 shows this embodiment. Chuck 100 carrying electrostatic printing plate 102 is transported on linear bearings 104 by belt drive 106, canted at roughly a 45° angle to the horizontal. At the beginning of the print cycle chuck 100 starts at the top near pulley 108. Moving at uniform speed it passes corona unit 110 which charges the printing plate, 102 with a uniform electrostatic charge. After a short period of time, the low resistivity areas of the plate with discharge to a negligible charge level; the high resistivity areas of the plate retain the charge to near original levels.

This latent electrostatic image is now developed by liquid toner which floods the gap between developer roll 112 and plate 102. Valve 114 floods this gap with a measured quantity of liquid toner 116. Developer roll 112 has an electrical bias voltage 118 which controls the accumulation of unwanted toner particles in background areas of the image. After passing between the developer roll plate 102 is stripped of excess liquids by reverse roll 120. After this the liquid toner is compacted by "depress" corona 122. The image is now finally developed and ready for transfer to the receiving substrate.

Receiving substrate 130 rests on its chuck 132 which rides on linear drive 134 driven by belts 136 and pulleys 138. It moves right past valve 140 which wets it with a thin layer of clear Isopar diluent. It moves to transfer position 142 and stops. Chuck 100 carrying printing plate 102 rotates approximately 135° counter clock wise to a position in obverse relation to receiving substrate 130. Spacing means not shown, accurately position plate 102 from receiving substrate 130 by a precisely controlled mechanical gap, typically of the order of 50μ to 150μ. A voltage is applied to chuck 132 to create a transfer electric field which transfers the toner image on plate 102 to receiving substrate 130.

Chuck 100 with printing plate 102 is now lifted vertically by means not shown or simply rotated clock wise by approximately 135° to its original position. Receiving substrate

130 is now dried before removing it from its chuck 132. Plate 102 is now moved up the 45° ramp and cleaned by suitable means, not shown, to repeat the next printing step.

The manifestation of the invention has advantages over the rotating process of the preferred embodiment in that is a ascychronous, i.e. variable time intervals can be introduced between each step of the process; and transfer occurs in the flat to flat situation when hydrodynamic events and forces have subsided. Furthermore, the flat receiving substrate, which may be of the order 1m x 1.2m must be on the bottom so it can be flooded by the diluent to fill the gap between the plate 102 and receiving substrate 130. Finally, the "overlay" accuracy of one flat plate, the printing plate; to a receiving sheet is much better, flat to flat, then in the dynamic situation of a moving flat sheet that needs to be accurately "phased" to a rotating print drum. Achieving very uniform linear and rotary drives are not trivial but phasing them "on the fly" to levels of their individual variations is a major task, all of which does not apply here.

Second Alternate Embodiment

Fig. 12 shows a cross section of the cathode plate 200 of an AC Plasma Color Display Panel. It consists of a glass back plate 200 with black glass spacer ribs 202 that optically and electrically isolated image cells from one another. These ribs are typically 100μ high and 30μ to 40μ in nominal width. At the bottom of the "wells" are the address electrode lines of copper 204 or nickel metal. Covering the walls and bottom of the "canyons" is the phosphor 206 that converts the UV radiation from the plasma discharge to visible radiation, RG&B in the case of a color display. Alternate canyons are coated with red, then green then blue phosphor.

One advantage of the electrostatic printing technique is the non-contact or gap transfer aspect of it; i.e. the ability to transfer functional materials across relatively large mechanical gaps.

Fig. 13 is a greatly magnified picture of the mechanical gap 220 between the print drum and glass surface 200 of the invention. The gap here is set to a value of 150μ. In the first manufacturing step glass toner is printed to make the spacer/isolator ribs 202. Four layers of toner 203 is shown, each about 25μ high, one printed on top of the other. The manufacturing sequence is as follows:

Step 1	Print first layer of glass ribs
Step 2	Dry the toner by blowing warm air on it to partially set the resinous material that coats the glass particles. Note it is desired to maintain this as a constant temperature process so warm air is needed to compensate for the natural cooling that occurs with the evaporation of the diluent liquid
Step 3	Reprint and dry the second layer of glass toner
Step 4	Reprint and dry subsequent layers of glass toner until the desired height is achieved.
Step 5	Fire the glass panel at high temperature to burn off the resin in the toner and reflow the glass particles to make a solid rib
Step 6	The rib manufacture process is now complete.

Figure 13 shows the process for the printing of the metallic address electrodes 204 in the base of the canyons formed by the ribs. A palladium catalytic toner 224 is image on the drum and transferred across the 150μ gap to the base of the canyons. The toner is dried leaving a very thin layer of palladium seeds in a line that runs the length of the canyons. The plate is removed from the printing machine of the invention and immersed in an "electroless" plating bath. Metal grows from solution is on the palladium seeds, then on previously plated metal. Electroless processes have advanced to a point where one can plate up to one micron

of metal per minute. After the growth of about 25μ of metal 226, usually nickel, the cathode electrodes are complete.

Figure 13 shows the deposition of phosphor toner 230 in the canyons. Phosphor toner 230 is imaged on the plate and transferred across the 150μ gap. Generally the transferred toner moves in straight lines but can coat relief images like coins. The toner image is sized to cover the walls of the canyons as well as the base where the electrodes are located. Note one phosphor color is imaged at a time so the printing plate has an image of every third canyon on it. After the first phosphor color 230 is imaged the toner is dried with warm air to set it; then the second color is imaged; then the third color. The same printing plate can be used for all three colors; all that is needed is to mechanically index the glass with respect to the printing drum.

The plasma display cathode plate is now finished. Glass ribs were built in 4 or 5 printing steps followed by a firing step to reflow the glass particles. Then electrodes were printed with a catalytic toner followed by an electroless plating step. Finally three color phosphors were printed in the canyons formed by the glass ribs.

Third Alternative Embodiment

An alternate method to produce conductors is to print metal toners themselves, to burn off the resin that coats the metal particles; then reflow the metal into a smooth conductor pattern. Using the invention of the preferred embodiment one prints an aluminum toner onto the glass. The toner is then dried to temporarily fix it for reasons of safe handling. Now a rapid thermal processing of the metal is effected, where the toner and glass is raised to a temperature of 50° to 100°C below the softening point of the glass (approximately 500°C for soda lime glass). This effectively burns off the resin that coats the metallic particles. Now with an intense UV light source, the aluminum is heated to its melting point while the glass absorbs little UV energy. Aluminum which melts at 659°C is a good choice of materials to

be used with soda lime glass. Note this is not done in air but in a "reducing" atmosphere like one used in aluminum welding work.

Fourth Alternate Embodiment

In this embodiment the glass 300 in Fig. 14a is first coated with a thin, transparent layer 301 that is electrically conductive. This very thin layer is not shown. Indium Tin Oxide (ITO) is a possibility except it absorbs about 5 to 10% of the transmitted light and ITO processing is expensive, of the order of $5 per square foot. The ITO conductivity of 50 to 100 ohms per square for a typical 2μ thick layer is higher than needed for this electrostatic process. A conducting polymer as resistive as 10^{+5} ohms per square is adequate for this electrostatic process, all that is needed is to establish an electrostatic ground plane 302 as shown in Fig. 14a.

In this case the coated glass 300 is imaged with the RGB color mosaics 304 which are then reflowed by final heating. The plate is now complete except for the black intermatrix which has yet to be produced. Transparent conductive layer is electrically grounded through edge contact 306 as shown in Fig. 14a. Now the entire plate is corona charged with a suitable corona generator 308 as in Fig. 14a. The conductive under layer discharges immediately, while the color mosaics retain their charge 310 for considerable periods of time, as much as thousands of a second depending on the resins used in the mosaics. The partially finished color filter plate is now its own electrostatic printing plate, as seen in Fig. 14b. It can be developed in the reversal mode (i.e. develop the discharged [or uncharged] areas of the image) as is done in virtually all desk top laser printers.

In the example shown, the mosaics are charged positively so a toner with a positive charge 312 will develop the non-charged areas as in Fig. 14c. This black toner will produce the intermatrix between the mosaics. After the toner is dried, it may be reflowed by heating

if necessary, but there are good reasons to leave it a particulate layer which will hold the unfused toner in place.

One of the principal advantages of this embodiment is that the final printing operation of the black intermatrix is self-correcting of "self-healing". Any image defects in the mosaics will be over printed with black toner automatically. Also one does not need a high definition printing plate for the black intermatrix which must then be aligned to micron tolerances so as not to leave gaps between matrix and mosaic through which stray light will be passed. This self-correction feature is one of the greatest advantages of this embodiment.

Another "self-printing" example as shown in this embodiment is seen in Fig. 14d. This glass plate #330 is typical of the face plate of a field emission display (FED). The glass is first coated with black chrome oxide #332 to enhance optical contrast and with a metallic chrome layer #334 to conduct away to ground the electrons that hit the phosphor. It is desired to coat phosphor in the bare spaces on the glass surface between the chrome fingers which are all connected together. To "self-print" the phosphor toner the glass panel is placed on an electrically ground plate #336, chrome side up. Using a wire or metallic probe #338 the chrome layer is made to act as an electrode by connecting it to a high voltage power supply, as high as possible before electrical breakdown occurs. Liquid toner is now poured over the plate and it is noted that toner #340 "develops" on the bare glass areas by means of the fringing electrical fields. If the toner particles have a positive charge on them, a positive voltage must be connected to the chrome layer; with negative toner conversely a negative voltage with respect to ground is needed. As before open area defects in the chrome layer will have toner deposited on them in a "self-healing" manner.

Example 1 of the Preferred Embodiment

An electrostatic printing plate was made by laminating DynaChem 5038, product of DynaChem Inc., Tustin California, photopolymer dry film resist material to 0.003 inches

thick black anodized aluminum foil from Lawrence and Frederick of Des Plaines, Illinois (the part number is 1145-003-1419-SB). The laminating was done on an industry standard dry film laminator made by Western Magnum. After cooling from the lamination process, the plate was exposed by a negative photo tool to nominal exposure level 100 milli joules/cm^2.

The plate was charged to a nominal image voltage of -800V by a corona discharge unit. After about 2 seconds it was developed with a glass particle liquid toner by merely pouring the toner over it. Clear diluent (typically Isopar G®, Exxon Corp.) was used to wash away background particles. 125μ thick spacers were placed on the plate edges and a glass plate wetted with diluent was placed over the spacers. Care was taken to ensure that no air bubbles were trapped in the space between the printing plate and the glass plate. The same corona unit was used to charge the top side of the glass plate with negative corona charges. The glass plate was lifted and an excellent glass toner image was found on the bottom surface of the glass plate. The glass was standard window glass (soda lime float glass) 0.090 inches thick.

Example 2 of the Preferred Embodiment

The glass toner of example 1, was prepared by the "organosol" process as taught by Kosel in US# 3,900,412. An organosol resin was polymerize in Isopar H diluent following the methods of Kosel. The resin had a Tg of -1 °C and a core to shell ratio of 4. It was designated the nomenclature of JB8-1 (Aveka Inc., Woodbury, Mn.) The toner contents were as follows:

75 gm glass powder, Ferro Corporation, Cleveland, Ohio, #EG-2030-VEG

25 gm resin, JB8-1

2 gm ZrHexCem, OMG Americas, Cleveland, Ohio, Prod. Cd. 949

300 gms of Isopar L®, Exxon Corporation

It was processed for one hour in a Dispermat F105® vertical bead mill made by Byk-Gardner Incorporated of Germany. Processing was done at medium speed. The resulting toner had the following characteristic:

mean particle size	1.27μ
toner conductivity	9.9 pico mho/cm
particle mobility	3.06 x 10^{-6} m^2/v • s
Z (or zeta) potential	14.7 millivolts

The glass particles have a true mass density of 5.2 while the Isopar L® has a density of 0.8 so the toner settles out substantially in 15 to 30 minutes. It can be successfully re-dispersed by moderately shaking of the toner containers by hand.

Example 3 of the Preferred Embodiment

Example #1 was repeated with the toner of example #2 but the toner was transferred to Cr coated glass. 75mm x 75mm x 1.2mm Corning 7059® glass were sputter coated with 100nm to 150nm of pure chrome. The resulting surface had a brilliant shine to it. The Cr surface on the glass was wetted with Isopar and this wetted glass placed on the PET on a developed printing plate. The Cr surface was connected to a lab supply producing -1600V. Good glass toner images were transferred on the Cr coated glass. The PET spacers were 125μ thick.

Example 4 of the Preferred Embodiment

A catalytic toner was prepared with the following ingredients:

2 gm of Palladium powder, Aldrich Chemical # 32666-6

17 gm of organosol resin, JB-8-1

1 gm of ZrHexChem

100 gm of Isopar L

The mixture was dispersed in the vertical bead mill for 1.5 hours at 2,000 rpm. The resulting toner had these measured characteristics:

mean particle size	0.333μ
conductivity	169 p mho/cm

The toner was imaged using the plate of Example 1 and transferred to soda lime glass plates. These plates were dried then put into an electroless copper bath (typically Shippley CuPosit ™ 328, Shippley Inc, Marlboro Massachusetts) for 10 minute at 23°C. Significant copper metal was visible on the glass surface.

Example 5 of the Preferred Embodiment

An aluminum powder toner was prepared by the following formulas:

75 gm of Alex Al, Argonide Corp.

25 gm of organosol resin JB-8-1

2 gm of ZrHexChem

350 gm Isopar L

The mixture was dispersed for 1.5 hours in the vertical bead mill and the resulting toner specifications were:

mean particle size	30μ
mobility	6.95×10^{-11} $m^2/v \bullet s$
conductivity	40 p mho/cm
zeta potential	5,314 m volts

The toner was imaged on the plate of example 1 and transferred to the same type to soda lime glass. After drying it was subjected to rapid thermal processing in the model CP-3545 RTP machine of Intevac of Rocklin, California. The toner and glass were pre-heated to 550°C in a non-oxidizing atmosphere. It was then exposed to intense UV radiation that heated the aluminum toner but not the glass.

Example 1 of the Fourth Alternate Embodiment

A 1.1mm thick plate of soda lime glass was patterned with black chrome oxide, then metallic chrome with phosphor openings of 60μ by 130μ in a solid pattern of 75mm x 100mm. The plate was placed, chrome side up on a grounded copper plate. Electrical contact was made with the chrome surface and the power supply was turned on to +6,000 volts. No break down occurred. The chrome surface was flooded with the phosphor containing toner Similar to Example #2, the difference was equal amounts of phosphor and resin, 50g of phosphor, 50g of JB8-1. Unwanted background was washed away with clear Isopar G. The plate was allowed to air dry at room temperature. Good phosphor toner images were noted in the clear spaces between the chrome fingers. The phosphor toner NP-1053A was obtained from Nichia Kagaku Kogyo, K.K., Tokashima-ken, Japan.

Example 1 of the First Alternate Embodiment

A printing plate from 38 micron thick DynaChem 5038 photopolymer was charged and imaged with Indigo E-1000 toner with a concentration of 1.5% by weight and a conductivity of 25 pico mhos/cm. Corning 7059 glass 1mm thick was placed on PET film, 25 microns thick spacers, above the plate. The gap between glass and plate was filled with pure Isopar G whose conductivity is less than 0.15 pico mho/cm. An electrode was placed on top of the 7059 glass and excited to +10kv with respect to the grounded base of the printing plate. The transfer voltage was held for 10 minutes.

The glass was removed with the transfer voltage still applied and it was noted that no toner transferred. This shows that virtually all of the voltage appeared across the glass and none or little across the gap so no toner transferred.

Initially toner may have transferred to the glass due to the capacitive division of voltages between glass and gap (theoretically about 12% of the 10kv or 1200 v), but as the voltage across the gap collapses, the toner would back transfer to the plate.

Example 2 of the First Alternate Embodiment

The plate of Example 1 of the First Alternate Embodiment was imaged and developed. Electroveere glass ELC-7401 with a resistivity of $2 \times 10^{+12}$ ohm • cm was placed on 50 micron thick PET spacers. The gap between glass and plate filled with Isopar G spiked with Indigo Imaging Agent to a conductivity of 12.4 pico mho/cm. A transfer voltage of 4kv was applied to the top of the Electroveere glass for 5 seconds while linearly reducing it to 3kv. The glass was removed with the 3kv transfer voltage still applied.

An excellent image was seen on the glass with very good edge acuity. The image was superior to a similar image created, using just clear Isopar G (i.e. very low conductivity) to fill the gap. Demonstrating that the charges, on the toner particles, are better preserved with the conductive, gap filling liquid.

Example 3 of the First Alternate Embodiment

An image was created on the plate of Example 1 of the First Alternate Embodiment using that toner. 2.25mm thick soda lime float glass (i.e. common window glass) was placed on 50 micron PET spacers, above the plate. Isopar G conductivity treated with Indigo Imaging Agent to a conductivity of 25 pico mho/cm was used to fill the gap between glass and plate. An electrode connected to 5kv of voltage was placed on top of the plate, which was reduced to 3kv in 5 seconds. The glass plate was lifted and an image of low density was found on the glass. A significant amount of toner remained untransferred on the printing plate. The conductivity of the gap liquid reduced the effective voltage across the gap causing poor transfer.

If clear Isopar G is used good, complete transfer occurs though edge acuity may suffer. With this moderately resistive glass (of the order 10^{+13} ohm • cm), the conductive Isopar in the gap reduces the voltage across the gap resulting in incomplete transfer.

In summary, this invention comprises a relatively uncomplicated high yield manufacturing process in which functional materials are configured as liquid electrographic toners that can be printed at commercially interesting rates of production in a non-contact mode. This non-contact feature allows one to print on non-flat surfaces or even relief surfaces such as ribbed surfaces.

While the invention has been described with reference to the preferred embodiments thereof it will be appreciated that various modifications can be made to the parts and methods that comprise the invention without departing from the spirit and scope thereof.

What is claimed is:

Claim 1. An apparatus for the printing of functional toners on a flat glass plate, said apparatus comprising:

a. an electrostatic printing plate (10) including a polymer layer (52) bonded to an electrically conducting substrate (54) that is electrically grounded;

b. a first corona unit means (12) for electrically charging said electrostatic printing plate with ions from a corona discharge thereby sensitizing it and defining charged and uncharged areas;

c. a liquid development unit (16) which is electrically biased to deposit functional toner particles (50) on said uncharged areas of said electrostatic printing plate;

d. a transfer station (48) in which said flat glass plate (26) is moved into close proximity to said electrostatic printing plate (10), but not touching;

e. means (25) for filing the mechanical gap between said electrostatic printing plate and said glass plate with a clear toner diluent (44); and,

f. a second corona unit means (30) located near said glass plate (26) but away from said electrostatic printing plate (10) and which is electrically connected to a high voltage power supply (31) for creating a corona discharge which sprays free charges on said glass plate (26) and which creates an electrical field (23) that causes said toner particles (48) to transfer across the fluid filled gap (42) in an orderly manner.

Claim 2. The apparatus of claim 1 further comprising;

g. mechanical adjustment capability means located on said transferred corona unit including mechanical shutters (32) for controlling the exact position

where toner migration from said printing plate (10) to said glass plate (26) occurs;

h. cleaning unit means (36) for removing residual toner particles from said printing plate (10);

i. a drying station (27) where warm air is provided to dry said glass plate after imaging; and,

j. support means (28) for supporting said glass plate (26) on it's edges so that said free charges in said glass tightly bind toner particles to the surface of said glass plate (26) after transfer.

Claim 3. The apparatus of claim 1 further comprising:

k. positive phototool means for exposing said electrostatic printing plate to actinic radiation in order to cross-link the non-imaged elements of said printing plate (10) while the image elements are unexposed and not cross-linked.

Claim 4. The apparatus of Claim 1 wherein said discharge areas of said printing plate (10) develop said toner particles.

Claim 5. The apparatus of Claim 4 wherein the polarity of said corona ions is identical to that of the toner particles in the liquid toner (50).

Claim 6. The apparatus of Claim 1 wherein said developer unit (16) includes an electrode (18, 22) which is electrically biased to a value approximately equal to the charged voltage of said printing plate (11).

Claim 7. The apparatus of Claim 1 wherein said receiving glass plate (26) is dried of excess liquid (46) by air (27) at substantially room temperature which is blown thereover to partially fix said toner.

Claim 8. The apparatus of Claim 1 wherein said toner comprises at least three functional particle toners.

Claim 9. A method for producing charged areas on an electrostatic printing plate which is to be developed with toner particles, by the steps of:

a. exposing said plate with a negative photo tool;

b. using corona discharge (12) to generate ions of the opposite polarity to the toner (50); and,

c. biasing the developer unit electrode to approximately 100 volts more than the image plate (11) voltage, in the background areas.

Claim 10. An apparatus (134) for the printing of functional toners on a flat glass plate, said apparatus comprising:

a. a flat electrostatic printing plate (102, 134) including a polymer layer (52) bonded to an electrically conducting substrate (54) that is electrically grounded;

b. a first corona unit means (114) for electrically charge said flat electrostatic printing plate (102) with ions (110) from a corona discharge thereby sensitizing it and defining charged and uncharged areas;

c. a liquid development unit (112) which is electrically biased to deposit functional toner particles on said uncharged areas of said flat electrostatic printing plate (102);

d. a reverse roller unit (120) means for mechanically removing excess diluent liquid from the developed plate (102);

e. a depress corona (122) to compact the toner particle pile before transfer;

f. a transfer station (124) in which said flat electrostatic printing plate (102) is moved in close proximity to a flat receiving glass substrate (124);

g. means (126) for filling the mechanical gap between flat printing plate (102) and flat receiving glass (124) with clear toner diluent (126); and,

h. a second corona unit means (128) located near said glass plate (124) but away from said electrostatic plating plate (102) which is electrically connected to a high voltage power supply for creating a corona discharge which sprays free charges on said glass plate (124) and which creates an electrical field that causes said toner particles to transfer across the fluid filled gap in an orderly manner.

Claim 11. The apparatus of Claim 10 further comprising;

i. electronic control mean (130) for providing adjustable time delays between each step of the process to achieve optimum image quality; and,

j. means more resistive than the glass (124) for supporting said glass plate (124) on its edges (132) so that said free charges in said glass (124) tightly bind toner particles on the surface of said glass plate after transfer, without distortion due to edge charge leakage.

Claim 12. The apparatus of claim 10 wherein the diluent fluid filling the gap (42) has an electrical conductivity from 0.15 to 100 pico siemens per centimeter.

Claim 13. The apparatus of Claim 10 wherein said printing plate (102) comprises a reimagable photoreceptor plate (134, 102), comprising an amorphous selenium layer, which is sensitized by a corona discharge (110) and imaged by an optical means, such as a scanned laser beam (111).

Claim 14. The apparatus of Claim 10 wherein a glass particle toner (203) is transferred to said glass plate (200) and the toner image (203) is dried with warm air to partially set the resin coating the glass particles and wherein successive layers of toner (203) build up a structure of a predetermined height.

Claim 15. The apparatus of Claim 10, wherein a palladium catalytic toner (224) is imaged on a relieved, or ribbed, glass panel (200) and subsequently plated with a metal to generate an electrode structure (204).

Claim 16. The apparatus of Claim 10 wherein a phosphor particle toner (230) is printed in a manner to coat a relieved structure (230) with a ribbed glass panel (200) having electrode lines (204) between said ribs (202).

Claim 17. An apparatus for the production of color for the black matrices on a flat plate (301) of said apparatus comprising:

a. a color filter plate (301) with an electrical conductive coating (302) and color mosaic pattern (304), which coating (302) is electrically grounded;

b. a corona unit (308) to charge the mosaic pattern (304) with charges (310); and,

c. liquid toner (312) which develops in the uncharged areas of plate (301), the regions between the color mosaics (304),

wherein the polarity of the toner particles (312) is identical to the polarity of the corona generated charges (310).

Claim 18. The apparatus of Claim 17 further comprising:

d. means (314) for drying and reflowing the toner image (312) on said coated glass plates (301);

e. means (306) for electrically grounding the conductive layer under said toner image; and,

f. means (308) for corona charging said toner image (312);

wherein said liquid developer unit deposits black toner particles in said un-charged areas or the bare regions of said plate between said color mosaics (304).

Claim 19. The apparatus of Claim 17 wherein said glass coating (302) is 0.5μ to 25μ thick.

Claim 20. The apparatus of Claim 17 wherein said glass coating (302) yields a resistivity of 1 ohms per square to 10^{10} ohms per square.

Claim 21. The apparatus of Claim 17 wherein said glass coating (302) is preferably in the range of 10^1 to 10^8 ohms per square.

Claim 22. An apparatus for the production of phosphor patterned glass plates comprising:

a. a glass plate (330) patterned with a metallic, conductive materials (332, 334) on its inside surface to conduct electronic charges to ground;

b. means to rest said plate (301) on an electrically grounded plate (336), with the conductive patterns (332, 334) facing in an outward direction;

c. means (338) for conducting said patterned conductive surface (332, 334) to a high voltage power supply (338) thereby generating an intense electric field between the patterned surface (332, 334) and said grounded plate (336);

d. means (341) for bringing liquid toner in contact with said patterned surface (332, 334) thereby depositing toner particles (340) with a charge of the same polarity as the voltage connected to the patterned surface (332, 334), in areas adjacent to said patterned surface (332, 334), but not on it;

e. means (342) for drying said liquid toner image; and ,

f. means (344) for reflowing said toner (340) by means of heat.

Abstract of the Invention

The invention describes techniques for the electrostatic printing of functional materials configured as liquid toners (50) on glass substrates (26) in a non-contact mode. The toners are patterned by a sensitized electrostatic printing plate (11) of fixed image configuration. Toner images (50) are transferred by an electric field (33) across a fluid filled mechanical gap (42) to the glass substrate (26). Techniques for optimizing the imaging and transfer processes are also disclosed. Two other techniques in which partially finished pieces are manipulated to "self-print" themselves, are described. In both cases defects in the pieces will over print the defect in the "self-healing" mode.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 2349-103 WO	**FOR FURTHER ACTION**	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/US99/23612	International filing date *(day/month/year)* 12 OCTOBER 1999	(Earliest) Priority Date *(day/month/year)* 13 OCTOBER 1998
Applicant ELECTROX CORPORATION		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 5 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (See Box I).

2. [X] **Unity of invention is lacking** (See Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] transcribed by this Authority.

4. With regard to the **title**,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is:

   Figure No. 1
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/23612

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT	International application No. PCT/US99/23612

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : B05D 05/06; B41J 02/41; G03G 15/10
US CL :347/112
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 347/112; 359/885; 399/237, 241; 427/64, 68, 164, 165

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPTO APS -BRS: "functional toner", diluent, solvent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,108,479 A (HIRANO) 28 April 1992 (28/04/92) ALL	1-8, 10-22
A	US 5,493,369 A (SYPULA et al.) 20 February 1996 (20/02/96) ALL	1-8, 10-16
A	US 5,533,447 A (JOHNSON et al.) 09 July 1996 (09/07/96) ALL	1-8, 10-21
A	US 5,544,582 A (BOCKO et al.) 13 August 1996 (13/08/96) ALL	1-8, 10-21
A	US 5,559,588 A (LARSON et al.) 24 September 1996 (24/09/96) all	1-8, 10-16
A	US 5,655,192 (DENTON et al.) 05 August 1997 (05/08/97) all	1-8, 10-161

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 FEBRUARY 2000	09 MAR 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-0844	Authorized officer WILLIAM A. NOE Telephone No. (703) 308-0956

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,701,815 A (BOCKO et al.) 30 December 1997 (30/12/97) all	1-8, 10-21
A	US 5,817,441 A (IWATA et al.) 06 October 1998 (06/10/98) all	1-8, 10-21
X	US 5,689,785 A (KATO et al.) 18 November 1997, (18/11/97) col. 34, lines 43-58.	9
A	US 4,243,735 A (KOBALE et al.) 06 January 1981 (06/01/81) all	22
A	US 5,240,798 A (EHEMANN, Jr.) 31 August 1993 (31/08/93) all	22

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claims 1-8 and 10-16, drawn to an apparatus for the printing of functional toners on a flat glass plate.
Group II, claim 9, drawn to a method for producing charged areas on an electrostatic printing plate.
Group III, claims 17-21, drawn to an apparatus for the production of color for black matrices on a flat plate.
Group IV, claim 22, drawn to an apparatus for the production of phosphor patterned glass plates.

The inventions listed as Groups I, II, III and IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical feature of the invention of Group I is a means for filling a mechanical gap between an aelectrostatic printing plate and a glass plate with a clear toner diluent. The special technical feature of the invention of Group II is a step of biasing a developing unit electrode to approximately 100 volts more than an image plate voltage in background areas. The special technical feature of the invention of Group III is a color filter plate with an electrical conductive coating and color mosaic pattern. The special technical feature of the invention of Group IV is a glass plate patterned with metallic, conductive materials on its inside surface. Since none of the inventions of Groups I, II, III and IV share a common special technical feature, unity of invention is lacking.

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only
International Application No.
International Filing Date
Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)*	2349-103 WO

Box No. I TITLE OF INVENTION

"ELECTROSTATIC PRINTING OF FUNCTIONAL TONER MATERIALS FOR ELECTRONIC MANUFACTURING APPLICATIONS"

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

ELECTROX CORPORATION
400 Morris Avenue, Suite 124
Denville, New Jersey 07834
US

☐ This person is also inventor.

Telephone No.
(973) 983-7757

Facsimile No.
(973) 983-7787

Teleprinter No.

State *(i.e. country)* of nationality: US

State *(i.e. country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

DETIG, ROBERT H.
80 Deep Dale Drive
Berkeley Heights, New Jersey 07922
US

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: US

State *(i.e. country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

WOODBRIDGE, RICHARD C.
WOODBRIDGE & ASSOCIATES, P.C.
P.O. Box 592
Princeton, New Jersey 08542
US

Telephone No.
(609) 924-3773

Facsimile No.
(609) 924-1811

Teleprinter No.

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No.V DESIG[illegible]ON OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked):*

Regional Patent

☒ **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **SD** Sudan, **SZ** Swaziland, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☒ **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent:** **AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☒ **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* ....

National Patent *(if other kind of protection or treatment desired, specify on dotted line):*

☒ **AL** Albania ....
☒ **AM** Armenia ....
☒ **AT** Austria ....
☒ **AU** Australia ....
☒ **AZ** Azerbaijan
☒ **BA** Bosnia and Herzegovina ....
☒ **BB** Barbados
☒ **BG** Bulgaria ....
☒ **BR** Brazil ....
☒ **BY** Belarus
☒ **CA** Canada
☒ **CH and LI** Switzerland and Liechtenstein
☒ **CN** China ....
☒ **CU** Cuba ....
☒ **CZ** Czech Republic ....
☒ **DE** Germany ....
☒ **DK** Denmark ....
☒ **EE** Estonia ....
☒ **ES** Spain ....
☒ **FI** Finland ....
☒ **GB** United Kingdom
☒ **GE** Georgia ....
☒ **GH** Ghana ....
☒ **GM** Gambia
☒ **GW** Guinea-Bissau ....
☒ **HU** Hungary ....
☒ **ID** Indonesia
☒ **IL** Israel ....
☒ **IS** Iceland
☒ **JP** Japan ....
☒ **KE** Kenya ....
☒ **KG** Kyrgyzstan ....
☒ **KP** Democratic People's Republic of Korea ....
☒ **KR** Republic of Korea ....
☒ **KZ** Kazakhstan ....
☒ **LC** Saint Lucia
☒ **LK** Sri Lanka
☒ **LR** Liberia
☒ **LS** Lesotho ....
☒ **LT** Lithuania
☒ **LU** Luxembourg
☒ **LV** Latvia
☒ **MD** Republic of Moldova ....
☒ **MG** Madagascar ....
☒ **MK** The former Yugoslav Republic of Macedonia ....
☒ **MN** Mongolia
☒ **MW** Malawi ....
☒ **MX** Mexico ....
☒ **NO** Norway
☒ **NZ** New Zealand ....
☒ **PL** Poland ....
☒ **PT** Portugal ....
☒ **RO** Romania
☒ **RU** Russian Federation ....
☒ **SD** Sudan
☒ **SE** Sweden
☒ **SG** Singapore
☒ **SI** Slovenia ....
☒ **SK** Slovakia ....
☒ **SL** Sierra Leone
☒ **TJ** Tajikistan ....
☒ **TM** Turkmenistan ....
☒ **TR** Turkey ....
☒ **TT** Trinidad and Tobago ....
☒ **UA** Ukraine ....
☒ **UG** Uganda ....
☒ **US** United States of America ....
☒ **UZ** Uzbekistan ....
☒ **VN** Viet Nam ....
☒ **YU** Yugoslavia ....
☒ **ZW** Zimbabwe ....

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

☐ ....
☐ ....
☐ ....

In addition to the designations made above, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except the designation(s) of ______________ . The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM Further priority claims are indicated in the Supplemental Box ☐

The priority of the following earlier application(s) is hereby claimed:

Country *(in which, or for which, the application was filed)*	Filing Date *(day/month/year)*	Application No.	Office of filing *(only for regional or international application)*
item (1) US	13 October 1998 (13-10-98)	60/104,079	
item (2)	( )		
item (3)	( )		

Mark the following check-box if the certified copy of the earlier application is to be issued by the Office which for the purposes of the present international application is the receiving Office (a fee may be required):

☒ The receiving Office is hereby requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s): 1

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):* ISA/US

Earlier search *Fill in where a search (international, international-type or other) by the International Searching Authority has already been out or requested and the Authority is now requested to base the international search, to the extent possible, on the results of that earlier search. such search or request either by reference to the relevant application (or the translation thereof) or by reference to the search request:*

Country (or regional Office): Date *(day/month/year)*: Number:

Box No. VIII CHECK LIST

This international application contains the following number of sheets:

1. request	:	3 sheets
2. description	:	26 sheets
3. claims	:	5 sheets
4. abstract	:	1 sheets
5. drawings	:	15 sheets
Total	:	50 sheets

This international application is accompanied by the item(s) marked below:

1. ☒ separate signed power of attorney
2. ☐ copy of general power of attorney
3. ☐ statement explaining lack of signature
4. ☐ priority document(s) *identified in Box No. VI as item(s):*
5. ☒ fee calculation sheet
6. ☐ separate indications concerning deposited microorganisms
7. ☐ nucleotide and/or amino acid sequence listing (diskette)
8. ☒ other *(specify):* Postcard and Express Mail Certificat

Figure No. 1 of the drawings (if any) should accompany the abstract when it is published.

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Richard C. Woodbridge, Agent

For receiving Office use only

1. Date of actual receipt of the purported international application:
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority specified by the applicant: ISA/
6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

The demand must be *directly* . *the competent International Prelimina*[…]*ining* *.uthority or, if two or more Authorities are with the one chosen* *applicant.* *The full name or two-letter code of th*[…]*hority may be indicated by the applicant on the line*

IPEA/ US

PCT

CHAPTER II

DEMAND

under Article 31 of the Patent Cooperation Treaty:
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty.

For International Preliminary Examining Authority use only	
Identification of IPEA	Date of receipt of DEMAND

Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION		Applicant's or agent's file reference
International application No. PCT/US99/23612	International filing date *(day/month/year)* 12 October 1999 (12-10-99)	(Earliest) Priority date *(day/month/year)* 13 October 1998 (13-10-98)

Title of invention
ELECTROSTATIC PRINTING OF FUCNTIONAL TONER MATERIALS FOR ELECTRONIC MANUFACTURING APPLICATIONS

Box No. II APPLICANT(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)* ELECTROX CORPORATION 185 Union Avenue New Providence, NJ 07974 US	Telephone No.: (973) 983-7757 Facsimile No.: (973) 983-7787 Teleprinter No.:
State *(i.e. country)* of nationality: US	State *(i.e. country)* of residence: US

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*
DETIG, ROBERT H.
80 Deep Dale Drive
Berkeley, NJ 07922
US

State *(i.e. country)* of nationality:	State *(i.e. country)* of residence:
US	US

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

State *(i.e. country)* of nationality:	State *(i.e. country)* of residence:

☐ Further applicants are indicated on a continuation sheet.

Sheet No. 2

International application No. PCT/US99/23612

Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The following person is [X] agent [ ] common representative

and [X] has been appointed earlier and represents the applicant(s) also for international preliminary examination.

[ ] is hereby appointed and any earlier appointment of (an) agent(s) /common representative is hereby revoked.

[ ] is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.

Name and address: *(Family name followed by given name; for a legal entity, full official The address must include postal code and name of country.)*	
WOODBRIDGE, RICHARD C. WOODBRIDGE & ASSOCIATES, P.C. P.O. Box 592 Princeton, New Jersey 08542-0592 US	Telephone No.: (609) 924-3773 Facsimile No.: (609) 924-1811 Teleprinter No.:

[ ] Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No. IV STATEMENT CONCERNING AMENDMENTS

The applicant wishes the International Preliminary Examining Authority*

(i) [X] to start the international preliminary examination on the basis of the international application as originally filed.

(ii) [ ] to take into account the amendments under Article 34 of

[ ] the description (amendments attached).

[ ] the claims (amendments attached).

[ ] the drawings (amendments attached).

(iii) [ ] to take into account any amendments of the claims under Article 19 filed with the International Bureau (a copy is attached).

(iv) [ ] to disregard any amendments of the claims made under Article 19 and to consider them as reversed.

(v) [ ] to postpone the start of the international preliminary examination until the expiration of 20 months from the priority date unless that Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

Box No. V ELECTION OF STATES

[X] The applicant hereby elects all eligible States *(that is, all States which have been designated and which are bound by Chapter II of the PCT)* except..

(If the applicant does not wish to elect certain eligible States, the name(s) or country code(s) of those States must be indicated above.)

Sheet No. 3.

International application No.
PCT/US99/23612

Box No. VI CHECK LIST

The demand is accompanied by the following documents for the purposes of international preliminary examination:

For International Preliminary Examining Authority use only

			received	not received
1. amendments under Article 34				
description	:	sheets	☐	☐
claims	:	sheets	☐	☐
drawings	:	sheets	☐	☐
2. letter accompanying amendments under Article 34	:	sheets	☐	☐
3. copy of amendments under Article 19	:	sheets	☐	☐
4. copy of statement under Article 19	:	sheets	☐	☐
5. other *(specify)*:	:	sheets	☐	☐

The demand is also accompanied by the item(s) marked below:

1. ☐ separate signed power of attorney
2. ☐ copy of general power of attorney
3. ☐ statement explaining lack of signature
4. ☒ fee calculation sheet
5. ☒ other *(specify)*:
   Express Mail Certificate No. EL494560444US
   Postcard

Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).

Richard C. Woodbridge,Esq.

For International Preliminary Examining Authority use only

1. Date of actual receipt of DEMAND:

2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):

3. ☐ The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply. ☐ The applicant has been informed accordingly.

4. ☐ The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.

5. ☐ Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82.

For International Bureau use only

Demand received from IPEA on:

DKT
PCM

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: RICHARD C. WOODBRIDGE
WOODBRIDGE & ASSOCIATES, P.C.
P.O. BOX 592
PRINCETON, NJ 08542

PCT JUL 26 2000

WRITTEN OPINION

(PCT Rule 66)

	Date of Mailing (*day/month/year*) 21 JUL 2000
Applicant's or agent's file reference 2349-103 WO	**REPLY DUE** within TWO months from the above date of mailing

International application No.	International filing date (*day/month/year*)	Priority date (*day/month/year*)
PCT/US99/23612	12 OCTOBER 1999	13 OCTOBER 1998

International Patent Classification (IPC) or both national classification and IPC
IPC(7): B05D 05/06; B41J 02/41; G03G 15/10 and US Cl.: 347/112

Applicant
ELECTROX CORPORATION

1. This written opinion is the first (first, etc.) drawn by this International Preliminary Examining Authority.
2. This opinion contains indications relating to the following items:
   - I [X] Basis of the opinion
   - II [ ] Priority
   - III [ ] Non-establishment of opinion with regard to novelty, inventive step or industrial applicability
   - IV [X] Lack of unity of invention
   - V [X] Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application
3. The applicant is hereby invited to reply to this opinion.

When? See the time limit indicated above. ~~The applicant may, before the expiration of that time limit, request this Authority to grant an extension., see Rule 66.2(d).~~

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also For an additional opportunity to submit amendments, see Rule 66.4.
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 *bis*.
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 13 FEBRUARY 2001.

Name and mailing address of the IPEA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Susan S. Lee
Facsimile No. (703) 305-3230	Telephone No. (703) 308-2138

Form PCT/IPEA/408 (cover sheet) (July 1998)★

WRITTEN OPINION

International application No.

PCT/US99/23612

I. Basis of the opinion

1. With regard to the **elements** of the international application:*

[X] the international application as originally filed

[X] the description:

pages 1-26, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of ______

[X] the claims:

pages 27-31, as originally filed
pages NONE, as amended (together with any statement) under Article 19
pages NONE, filed with the demand
pages NONE, filed with the letter of ______

[X] the drawings:

pages 1-15, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of ______

[X] the sequence listing part of the description:

pages NONE, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of ______

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ______ which is:

[ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

[ ] the language of publication of the international application (under Rule 48.3(b)).

[ ] the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the written opinion was drawn on the basis of the sequence listing:

[ ] contained in the international application in printed form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readable form.

[ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. [X] The amendments have resulted in the cancellation of:

[X] the description, pages NONE
[X] the claims, Nos. NONE
[X] the drawings, sheets/~~fig~~ NONE

5. [ ] This opinion has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed".*

WRITTEN OPINION

International application No.
PCT/US99/23612

IV. Lack of unity of invention

1. In response to the invitation (Form PCT/IPEA/405) to restrict or pay additional fees the applicant has:

- ☐ restricted the claims. (See Supplemental Sheet)
- ☒ paid additional fees.
- ☐ paid additional fees under protest.
- ☐ neither restricted nor paid additional fees.

2. This Authority found that the requirement of unity of invention is not complied with for the following reasons and chose, according to Rule 68.1 not to invite the applicant to restrict or pay additional fees:

3. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this opinion:

- ☒ all parts.
- ☐ the parts relating to claims Nos. _.

WRITTEN OPINION	International application No. PCT/US99/23612

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	1-8 and 10-22	YES
	Claims	9	NO
Inventive Step (IS)	Claims	1-8 and 10-22	YES
	Claims	9	NO
Industrial Applicability (IA)	Claims	1-22	YES
	Claims	NONE	NO

2. citations and explanations

Claim 9 lacks novelty under PCT Article 33(2) as being anticipated by US 5, 689,785 (Kato et al.), column 34, lines 43-60, and column 92, line 59 - column 93, line 7.

Claim 9 lacks an inventive step under PCT Article 33(3) as being obvious over Kato et al. Kato et al. discloses a reversal development is made from a negative image that is irradiated with laser beam, and development is carried out by using a toner having a same polarity chargeablility as in the charging of photoreceptor. The photoreceptor 11 was corona charged to -600 V. Residual potential of the exposed area was -120 V. A development bias voltage of -200 V was applied to the development unit.

Claims 1-8 and 10-22 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest printing of functional toners on a flat glass plate (claims 1-8 and 10-16), an apparatus for the production of color for black matrices on a flat plate (claims 17-21), and an apparatus for the production of phosphor patterned glass plates (claim 22).

Claims 1-22 meet the criteria of PCT Article 33(4) because it has use in the printing art.

------------------- NEW CITATIONS -------------------
NONE

WRITTEN OPINION

International application No.

PCT/US99/23612

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

Sheet 10

TIME LIMIT:

The time limit set for response to a Written Opinion may not be extended. 37 CFR 1.484(d). Any response received after the expiration of the time limit set in the Written Opinion will not be considered in preparing the International Preliminary Examination Report.

IV. LACK OF UNITY OF INVENTION:

1. This response is made to a telephone Lack of Unity requirement (see telephone memorandum attached hereto or attached to a prior Written Opinion).

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s)1-8 and 10-16, drawn to an apparatus for the printing of functional toners on a flat glass plate.
Group II, claim(s) 9, drawn to a method for producing charged areas on an electrostatic printing plate.
Group III, claim(s) 17-21, drawn to an apparatus for the production of color for black matrices on a flat plate.
Group IV, claim 22, drawn to an apparatus for the production of phosphor patterned glass plates.
and it considers that the International Application does not comply with the requirements of unity of invention (Rules 13.1, 13.2 and 13.3) for the reasons indicated below:

The inventions listed as Groups I, II, III and IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical feature of the invention of Group I is a means for filling a mechanical gap between an electrostatic printing plate and a glass plate with a clear toner diluent. The special technical feature of the invention of Group II is biasing a developing unit electrode to approximately 100 volts more than an image plate voltage in background areas. The special technical feature of the invention of Group III is a color filter plate with an electrical conductive coating and color mosaic pattern. The special technical feature of Group IV is a glass plate patterned with metallic, conductive materials on its inside surface. Since none of the inventions of Groups I, II, III and IV share a common special technical feature, unity of invention is lacking.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 2349-103 WO	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US99/23612	International filing date *(day/month/year)* 12 OCTOBER 1999	Priority date *(day/month/year)* 13 OCTOBER 1998
International Patent Classification (IPC) or national classification and IPC IPC(7): B05D 05/06; B41J 02/41; G03G 15/10 and US Cl.: 347/112		
Applicant ELECTROX CORPORATION		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 10 sheets.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 1 sheets.

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of report with regard to novelty, inventive step or industrial applicability
   - IV [X] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application

Date of submission of the demand 19 APRIL 2000	Date of completion of this report 08 NOVEMBER 2000
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer Susan S. Lee Telephone No. (703) 308-2138

Form PCT/IPEA/409 (cover sheet) (July 1998) ★

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US99/23612

I. Basis of the report

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed

☒ the description:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

☒ the claims:
pages (See Attached), as originally filed
pages ______, as amended (together with any statement) under Article 19
pages ______, filed with the demand
pages ______, filed with the letter of ______

☒ the drawings:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

☒ the sequence listing part of the description:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ______ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages NONE

☒ the claims, Nos. NONE

☒ the drawings, sheets/~~fig~~ NONE

5. ☐ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

***Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

   ☐ restricted the claims.

   ☒ paid additional fees.

   ☐ paid additional fees under protest.

   ☐ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

   ☐ complied with.

   ☒ not complied with for the following reasons:

Please See Supplemental Sheet.

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

   ☒ all parts.

   ☐ the parts relating to claims Nos. .

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US99/23612

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	1-22	YES
	Claims	NONE	NO
Inventive Step (IS)	Claims	1-22	YES
	Claims	NONE	NO
Industrial Applicability (IA)	Claims	1-22	YES
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claims 1-22 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest printing of functional toners on a flat glass plate (claims 1-8 and 10-16), a method for producing charged areas on an electrophotographic printing plate by exposing the plate with a negative photo tool, using corona discharge to generate ions of the opposite polarity to the toner; and biasing the developer unit electrode to approximately 100 volts more than the image plate voltage, in the background areas (claim 9); an apparatus for the production of color for black matrices on a flat plate (claims 17-21), and an apparatus for the production of phosphor patterned glass plates (claim 22).

Claims 1-22 meet the criteria of PCT Article 33(4) because it has use in the printing art.

-------------------- NEW CITATIONS --------------------
NONE

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

Sheet 10

I. BASIS OF REPORT:

This report has been drawn on the basis of the description,
page(s) 1-26, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the claims,
page(s) 27, 29-31, as originally filed.
page(s) NONE, as amended under Article 19.
page(s) NONE, filed with the demand.
and additional amendments:
Page 28, filed with the letter of 25 September 2000.

This report has been drawn on the basis of the drawings,
page(s) 1-15, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the sequence listing part of the description:
page(s) NONE, as originally filed.
pages(s) NONE, filed with the demand.
and additional amendments:
NONE

IV. LACK OF UNITY OF INVENTION:

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2, and 13.3 is not complied with for the following reasons:

As applicant was previously notified this International Preliminary Examining Authority has found plural inventions claimed in the International Application covered by the claims indicated below:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s)1-8 and 10-16, drawn to an apparatus for the printing of functional toners on a flat glass plate.
Group II, claim(s) 9, drawn to a method for producing charged areas on an electrostatic printing plate.
Group III, claim(s) 17-21, drawn to an apparatus for the production of color for black matrices on a flat plate.
Group IV, claim 22, drawn to an apparatus for the production of phosphor patterned glass plates.

and it considers that the International Application does not comply with the requirements of unity of invention (Rules 13.1, 13.2 and 13.3) for the reasons indicated below:

The inventions listed as Groups I, II, III and IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical feature of the invention of Group I is a means for filling a mechanical gap between an electrostatic printing plate and a glass plate with a clear toner diluent. The special technical feature of the invention of Group II is biasing a developing unit electrode to approximately 100 volts more than an image plate voltage in background areas. The special technical feature of the invention of Group III is a color filter plate with an electrical conductive coating and color mosaic pattern. The special technical feature of Group IV is a glass plate patterned with metallic, conductive materials on its inside surface. Since none of the inventions of Groups I, II, III and IV share a common special technical feature, unity of invention

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

is lacking.

PCT/US99/23612
IPEA/US 25 SEP 2000

i. a drying station (27) where warm air is provided to dry said glass plate after imaging; and,

j. support means (28) for supporting said glass plate (26) on it's edges so that said free charges in said glass tightly bind toner particles to the surface of said glass plate (26) after transfer.

Claim 3. The apparatus of claim 1 further comprising:

k. positive phototool means for exposing said electrostatic printing plate to actinic radiation in order to cross-link the non-imaged elements of said printing plate (10) while the image elements are unexposed and not cross-linked.

Claim 4. The apparatus of Claim 1 wherein said discharge areas of said printing plate (10) develop said toner particles.

Claim 5. The apparatus of Claim 4 wherein the polarity of said corona ions is identical to that of the toner particles in the liquid toner (50).

Claim 6. The apparatus of Claim 1 wherein said developer unit (16) includes an electrode (18, 22) which is electrically biased to a value approximately equal to the charged voltage of said printing plate (11).

Claim 7. The apparatus of Claim 1 wherein said receiving glass plate (26) is dried of excess liquid (46) by air (27) at substantially room temperature which is blown thereover to partially fix said toner.

Claim 8. The apparatus of Claim 1 wherein said toner comprises at least three functional particle toners.

Claim 9. A method for producing charged areas on an electrostatic printing plate which is to be developed with toner particles, by the steps of:

a. exposing said plate with a negative photo tool;

b. using corona discharge (56) to generate ions of the opposite polarity to the toner (50); and,

c. biasing the developer unit electrode to approximately 100 volts more than the image plate (11) voltage, in the background areas.

Claim 10. An apparatus (134) for the printing of functional toners on a flat glass plate, said apparatus comprising:

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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(71) Applicant (*for all designated States except US*): ELECTROX CORPORATION [US/US]; Suite 124, 400 Morris Avenue, Denville, NJ 07834 (US).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): DETIG, Robert, H. [US/US]; 80 Deep Dale Drive, Berkeley Heights, NJ 07922 (US).

(74) Agent: WOODBRIDGE, Richard, C.; Woodbridge & Associates, P.C., P.O. Box 592, Princeton, NJ 08542 (US).

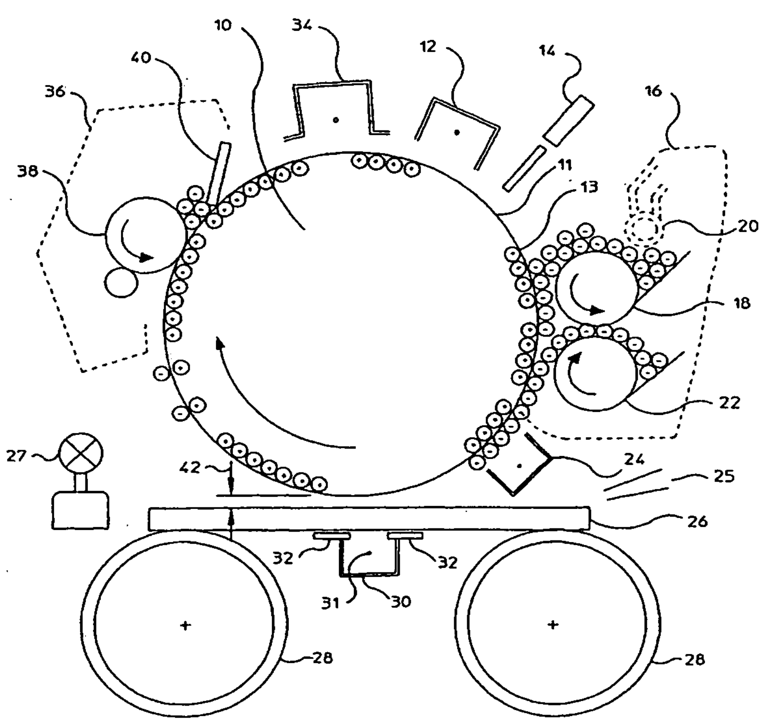
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: ELECTROSTATIC PRINTING OF FUNCTIONAL TONER MATERIALS FOR ELECTRONIC MANUFACTURING APPLICATIONS

(57) Abstract

The invention describes techniques for the electrostatic printing of functional materials configured as liquid toners (50) on glass substrates (26) in a non-contact mode. The toners are patterned by a sensitized electrostatic printing plate (11) of fixed image configuration. Toner images (50) are transferred by an electric field (33) across a fluid filled mechanical gap (42) to the glass substrate (26). Techniques for optimizing the imaging and transfer processes are also disclosed. Two other techniques in which partially finished pieces are manipulated to "self-print" themselves, are described. In both cases defects in the pieces will over print the defect in the "self-healing" mode.



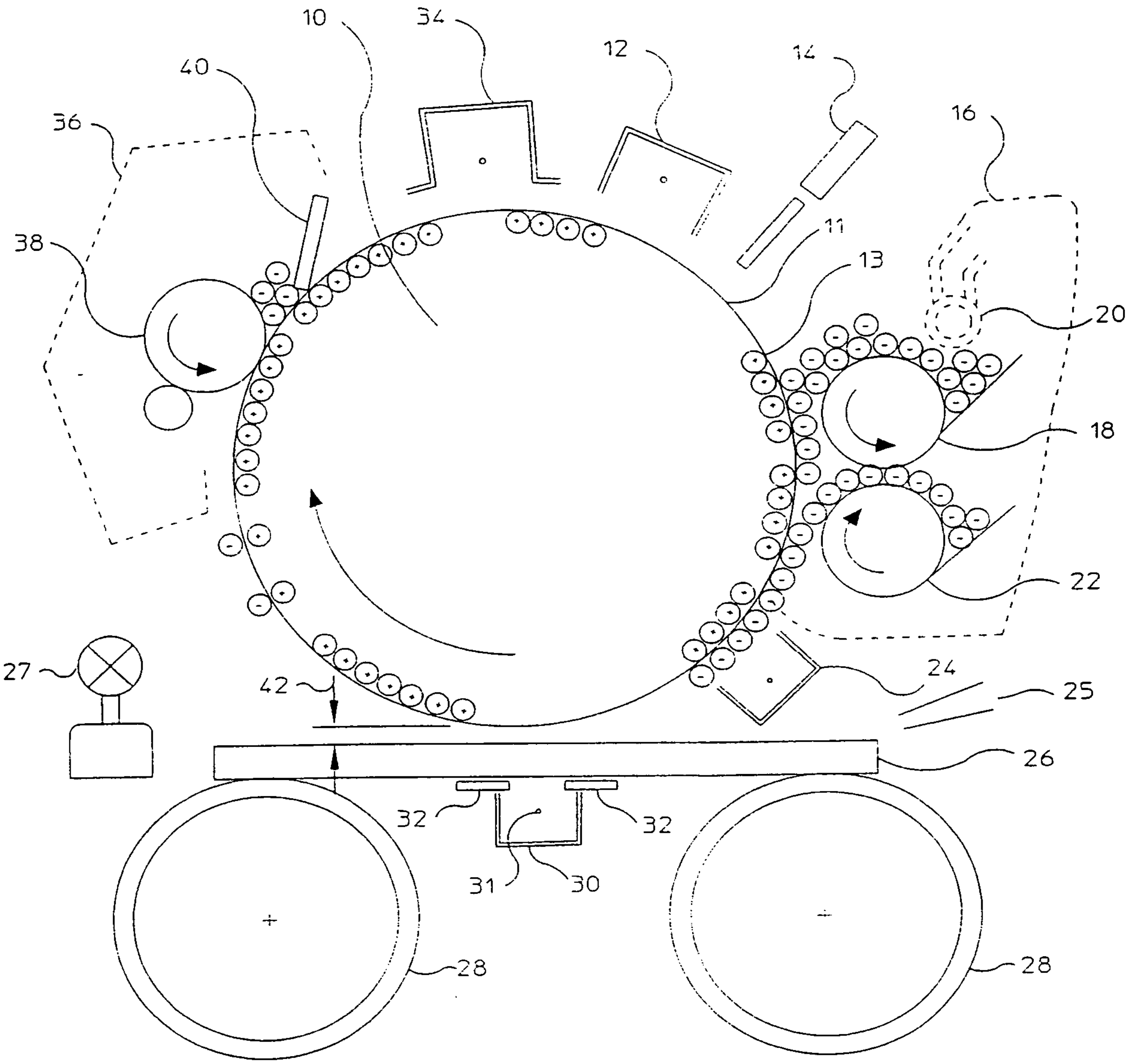


Fig. 1

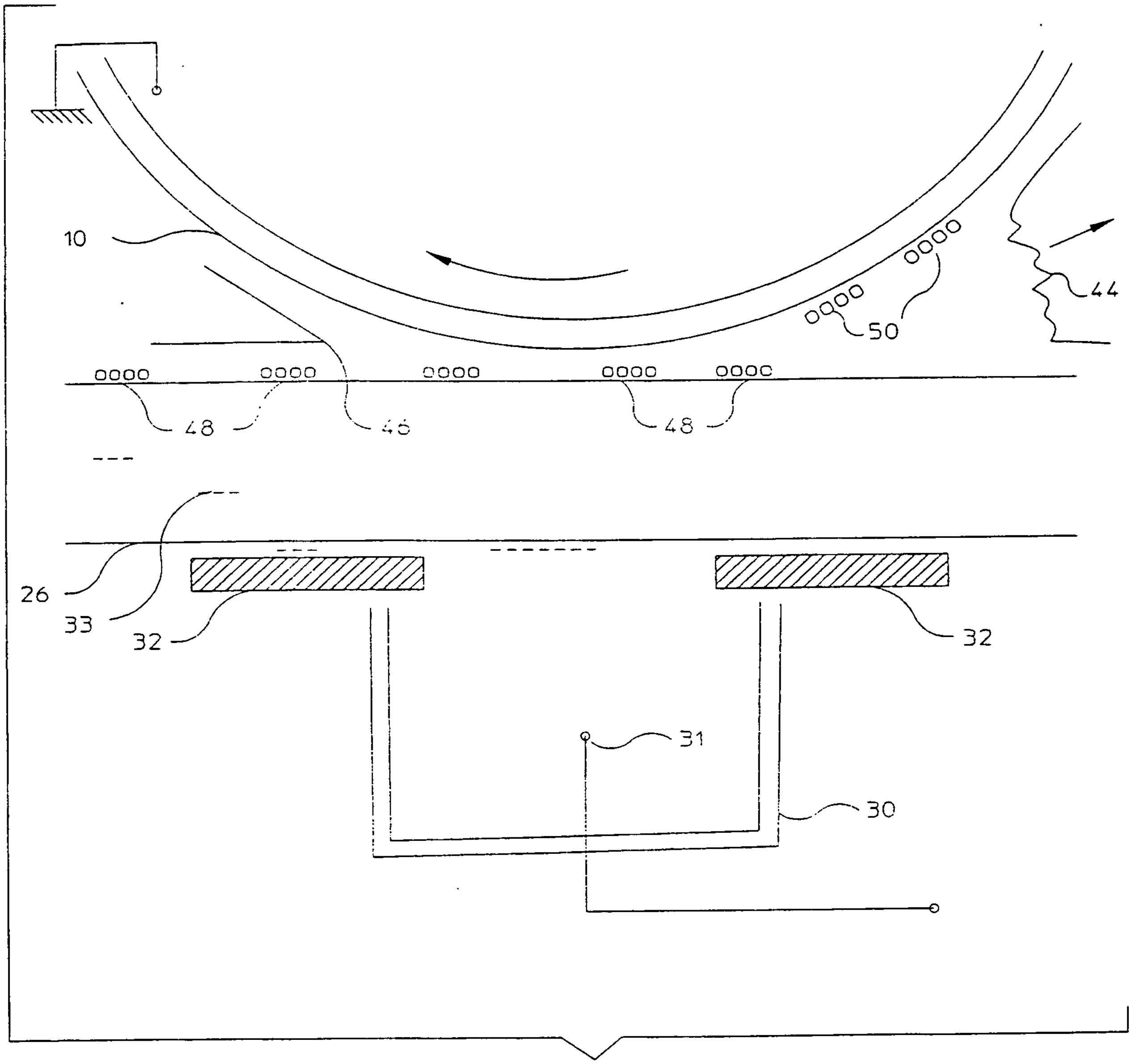


Fig. 2

Fig. 3A
EXPOSE

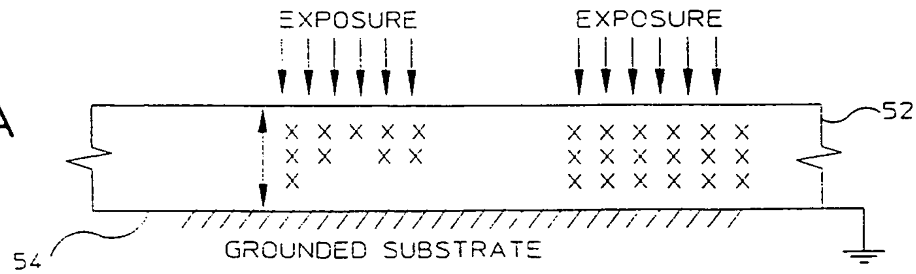


Fig. 3B
CHARGING

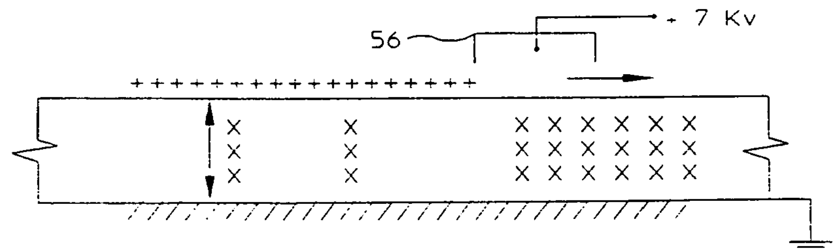


Fig. 3C
DELAY

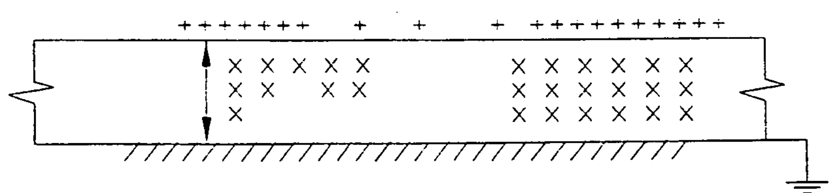
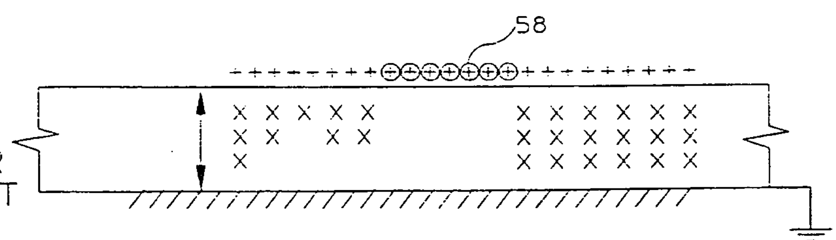


Fig. 3D
LIQUID TONER
DEVELOPMENT



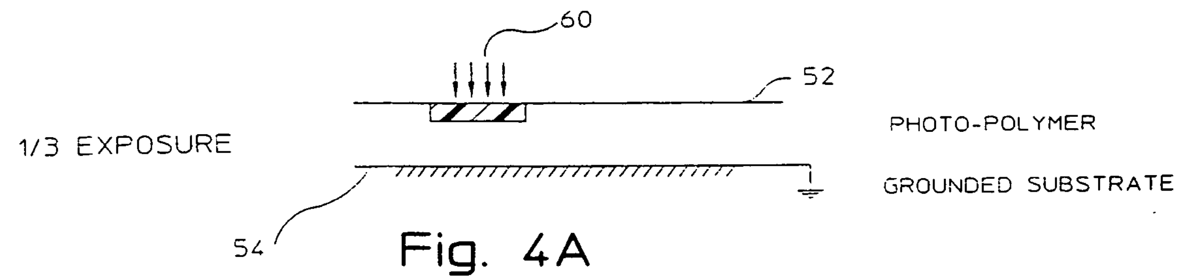


Fig. 4A

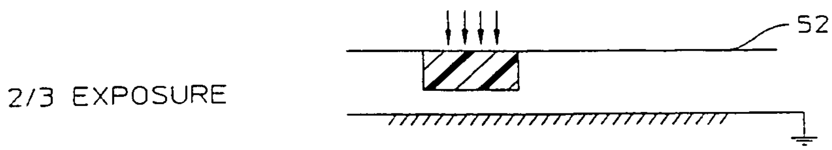


Fig. 4B

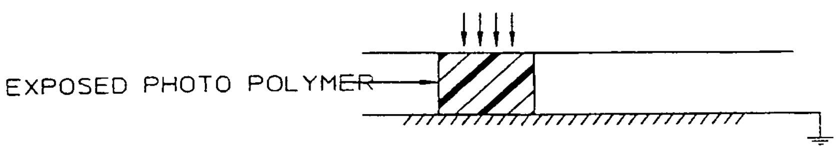


Fig. 4C

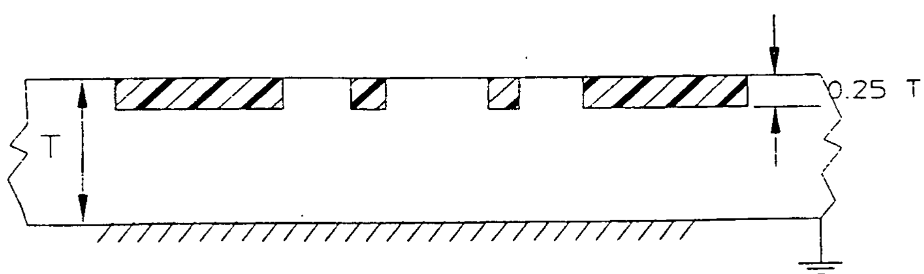


Fig. 4D

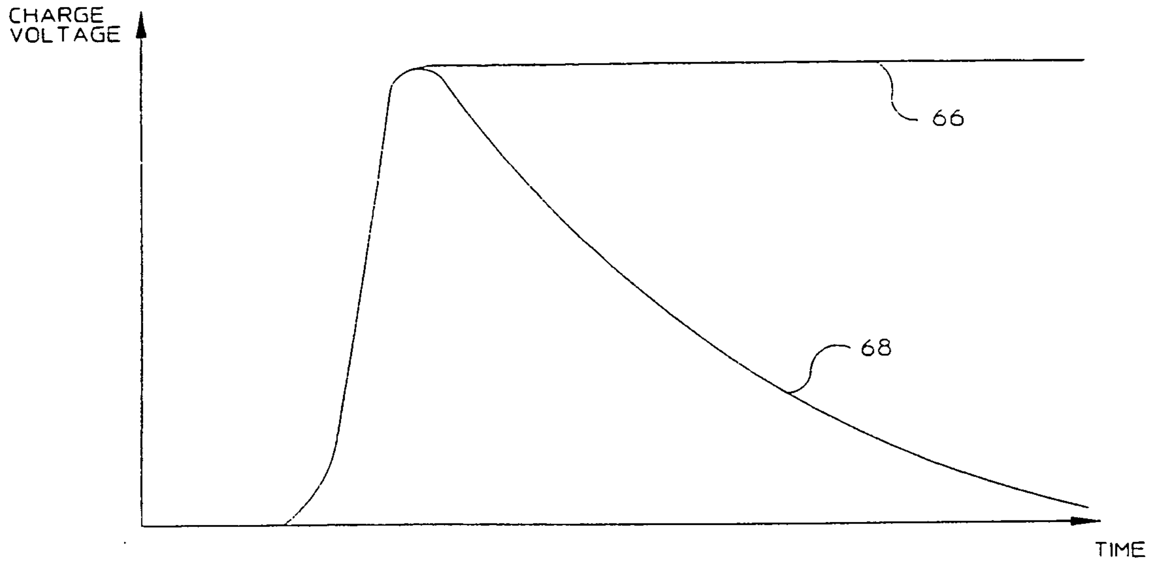


Fig. 5A

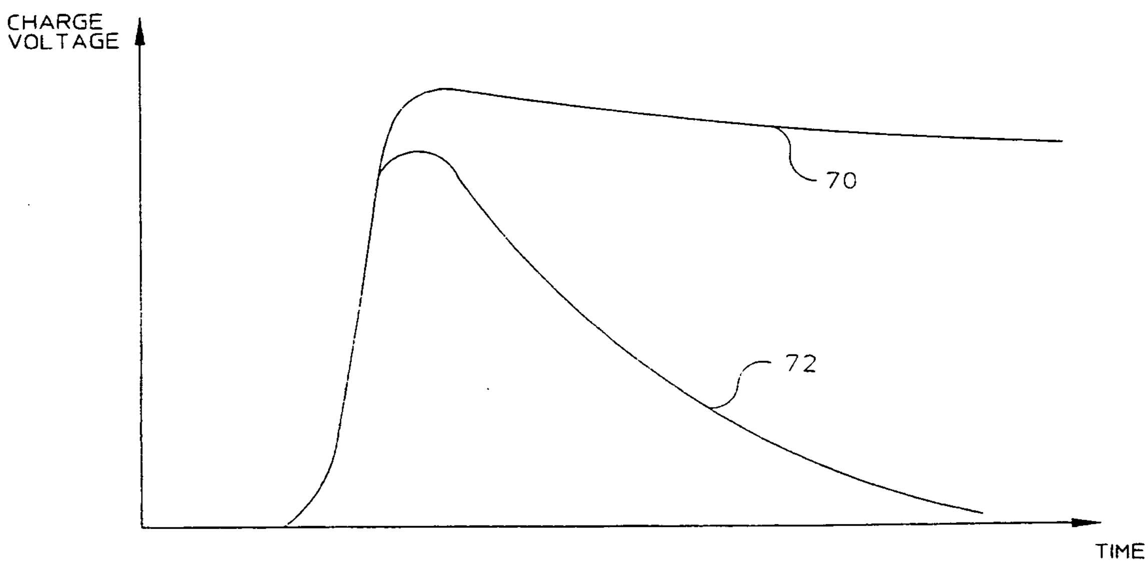


Fig. 5B

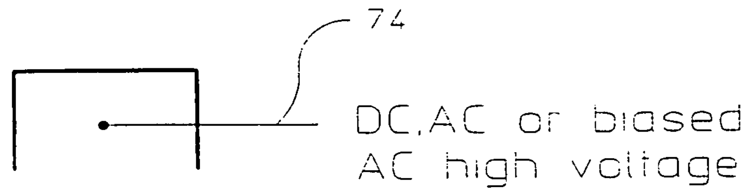


Fig. 6A

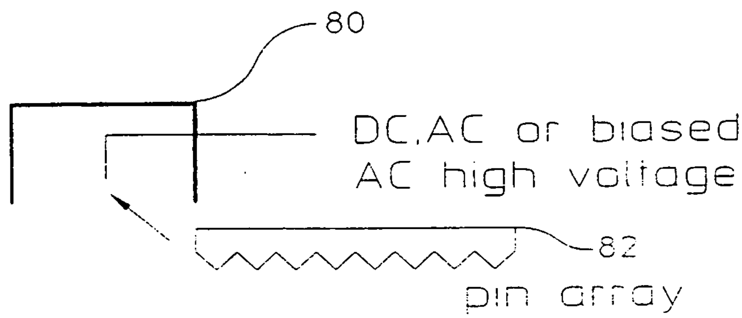


Fig. 6B

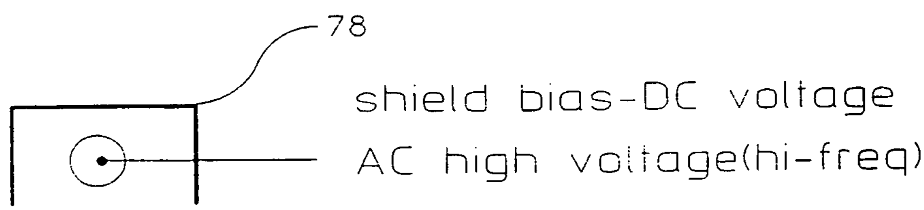


Fig. 6C

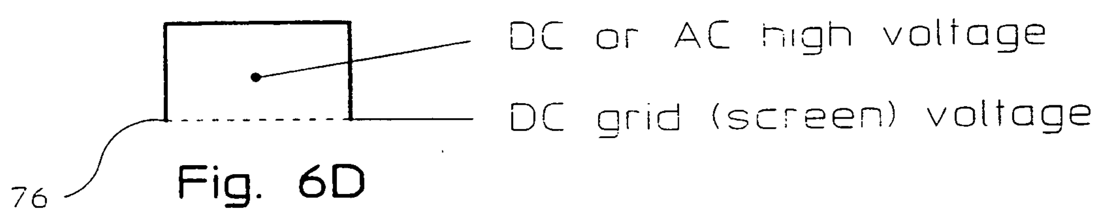


Fig. 6D

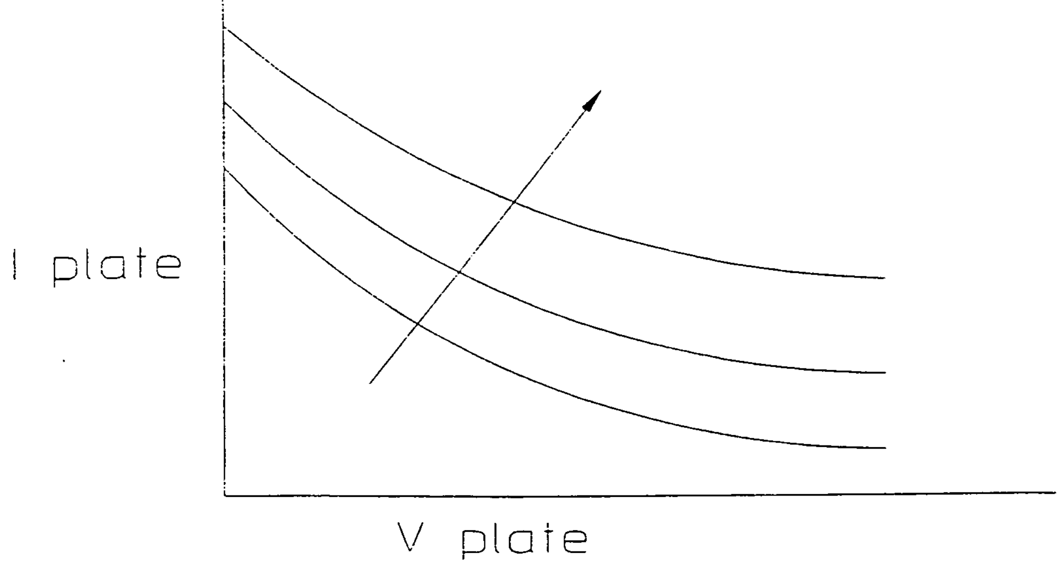


Fig. 7A

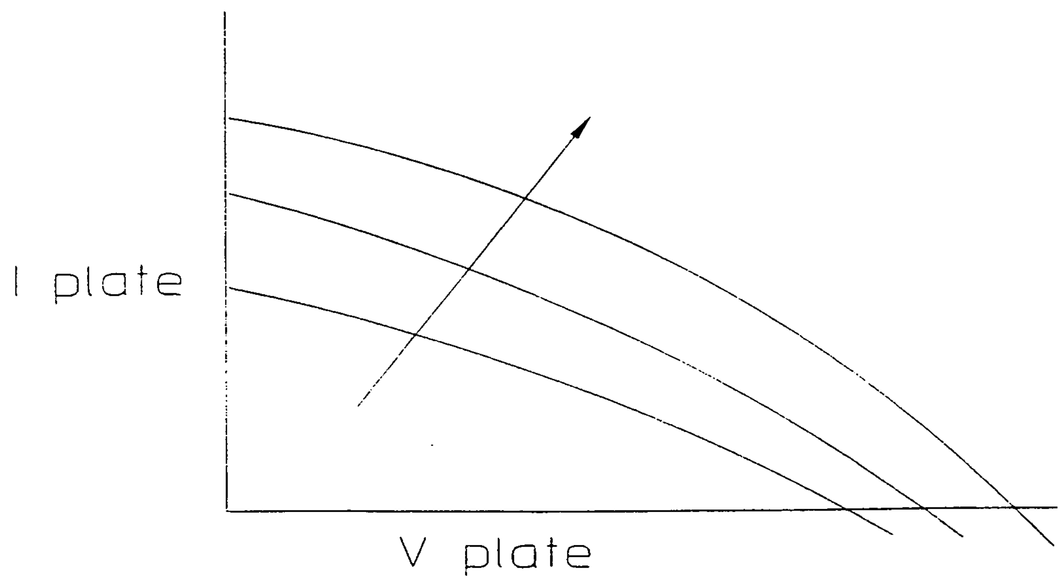


Fig. 7B

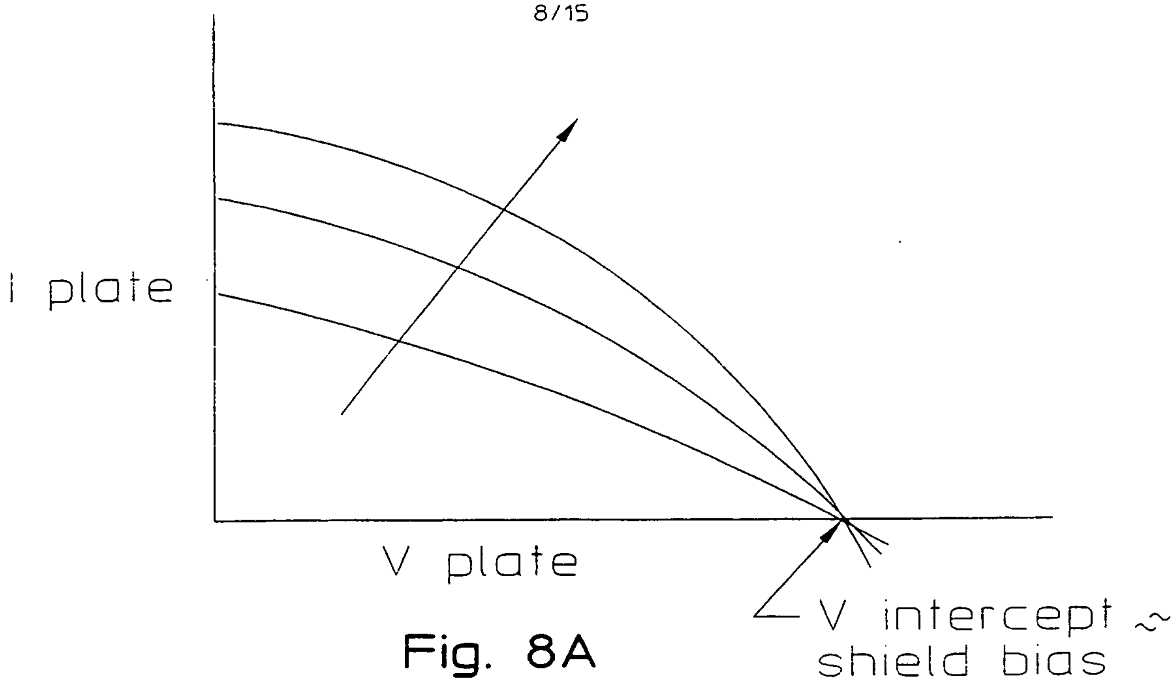

I plate
V plate
V intercept ~ shield bias

Fig. 8A

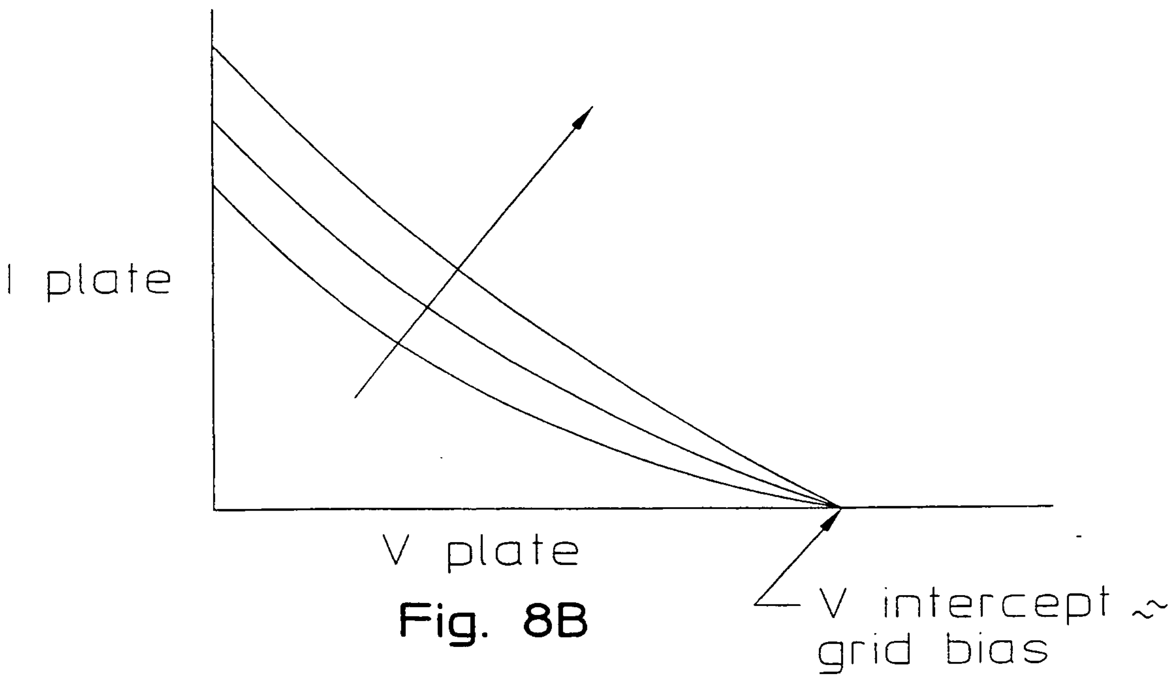

I plate
V plate
V intercept ~ grid bias

Fig. 8B

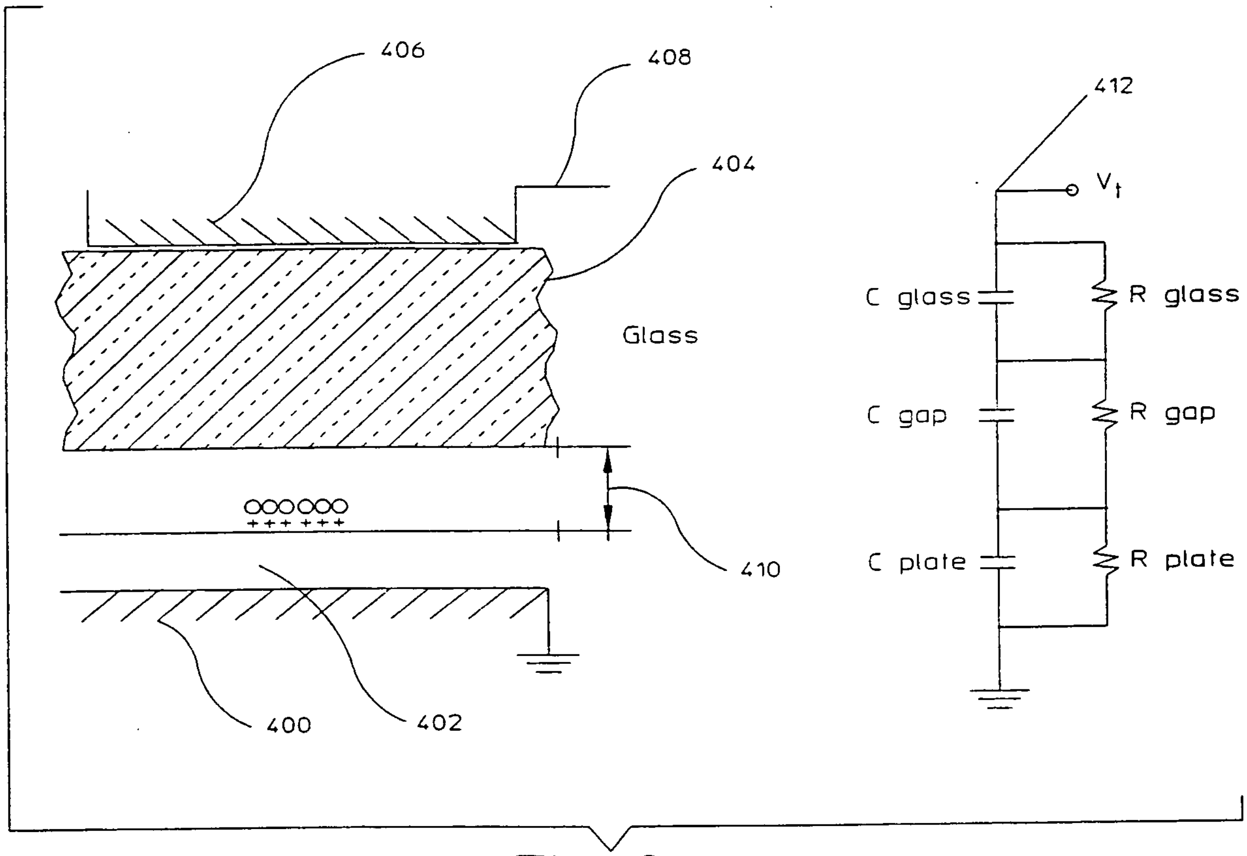

406
408
404
412
V_t
Glass
C glass
R glass
C gap
R gap
C plate
R plate
410
400
402

Fig. 9

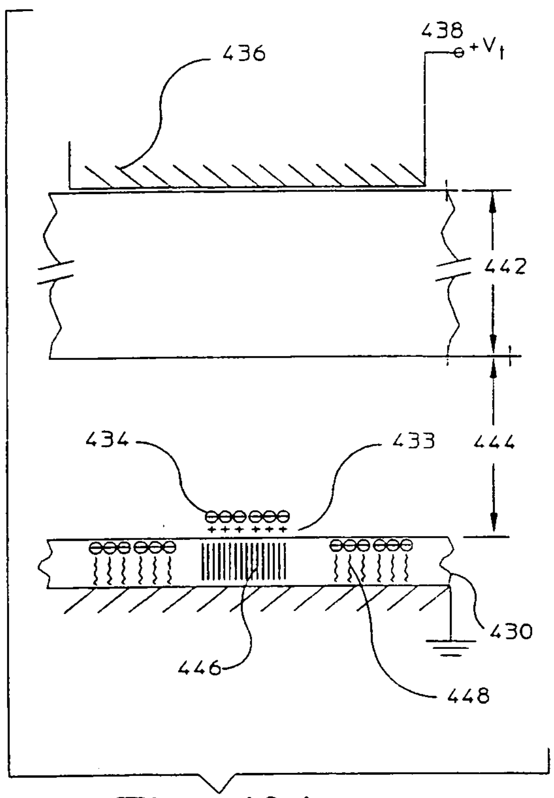


Fig. 10A

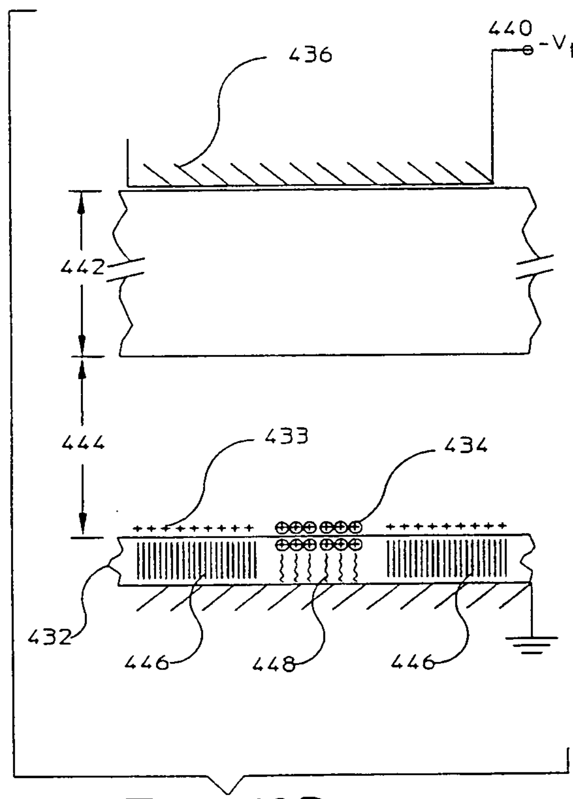


Fig. 10B

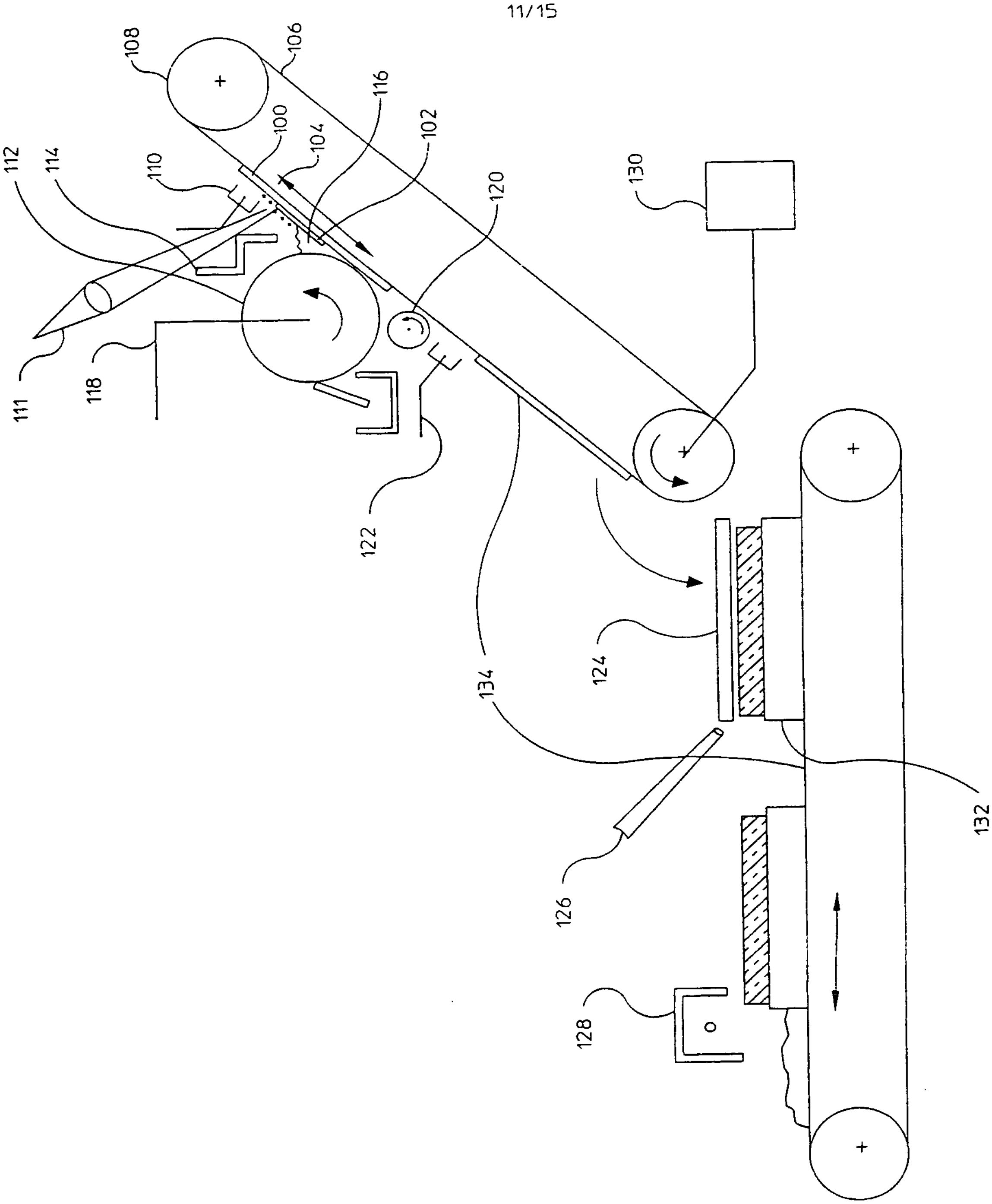

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Fig. 11

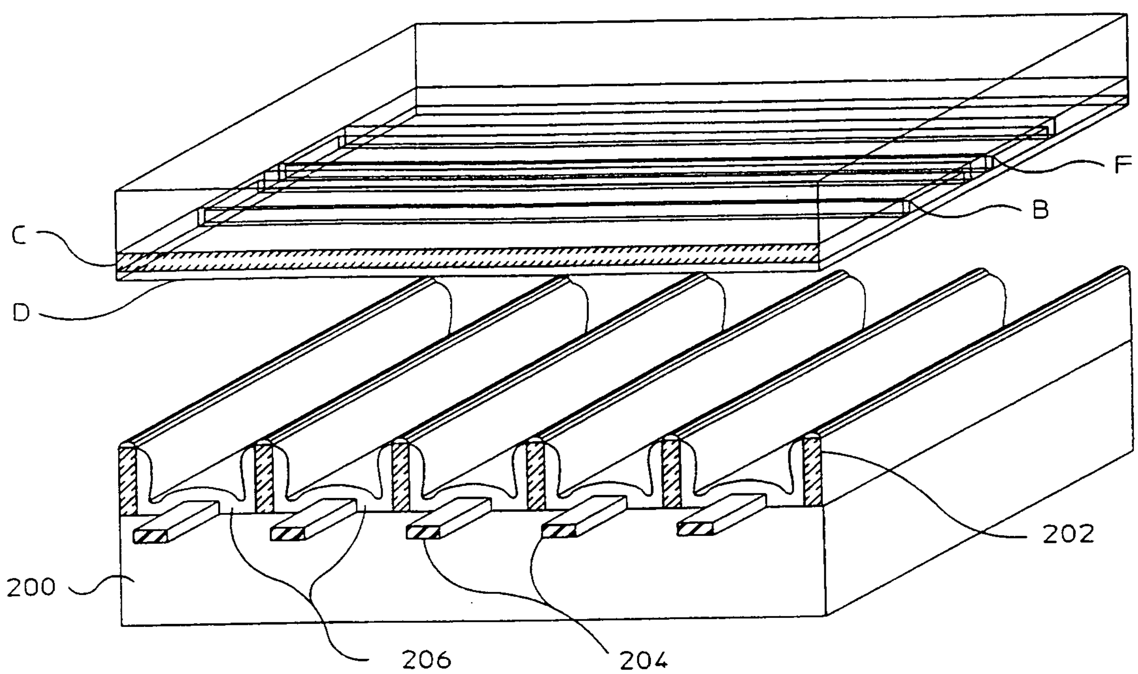

Fig 12

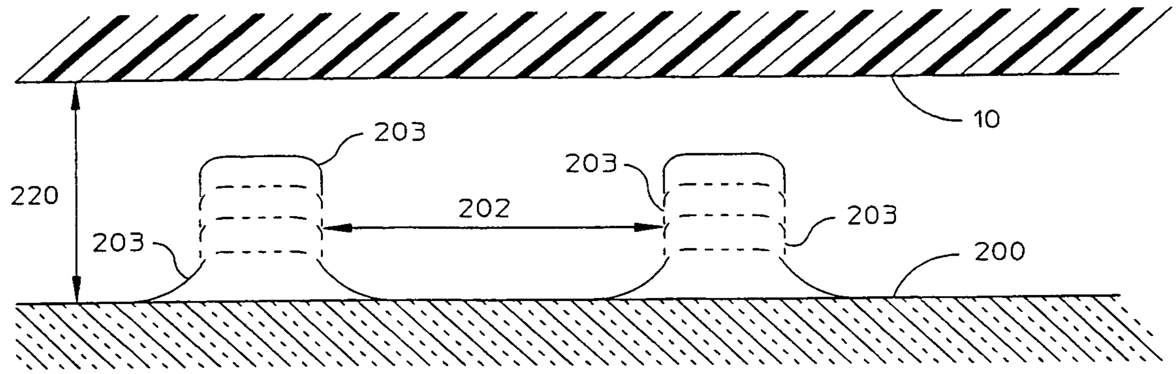

Fig. 13A

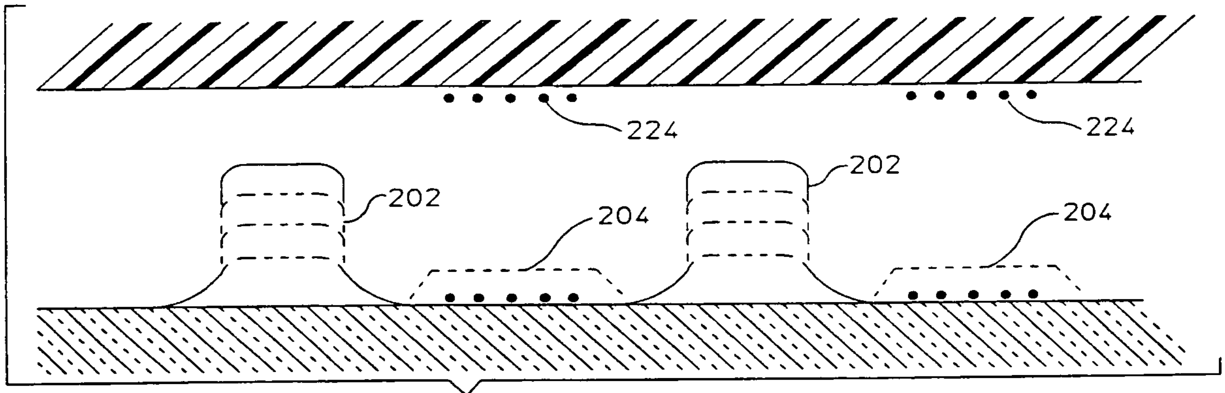

Fig. 13B

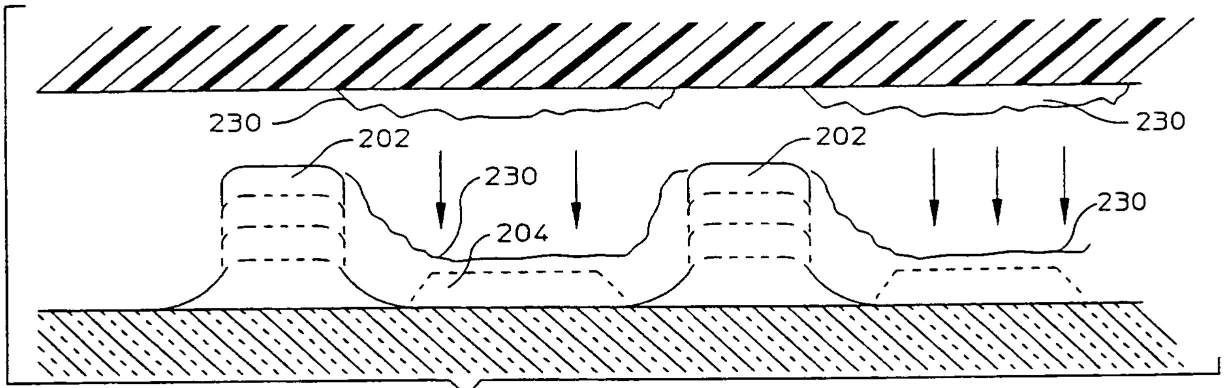

Fig. 13C

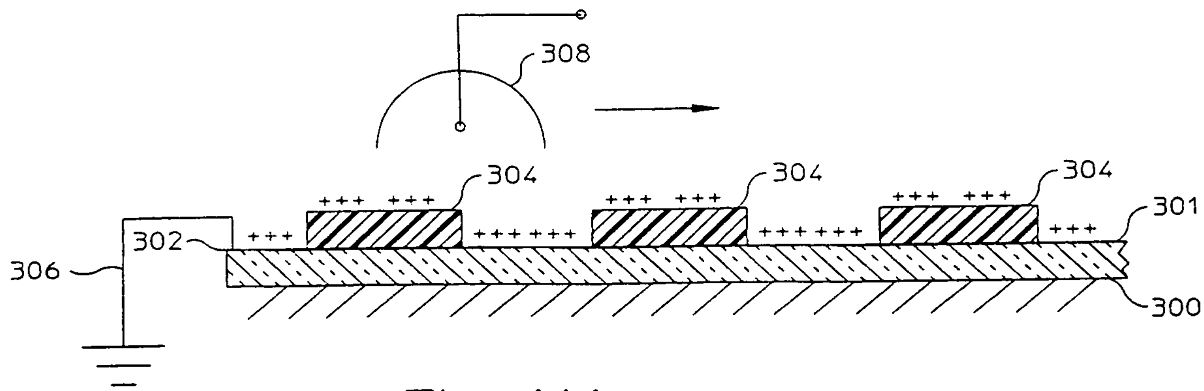

Fig. 14A

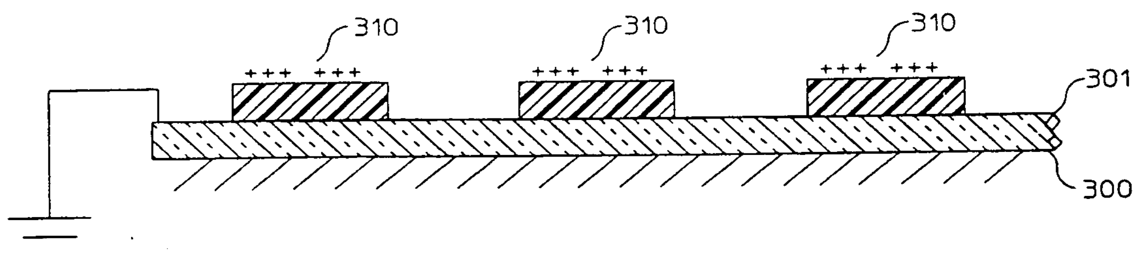

Fig. 14B

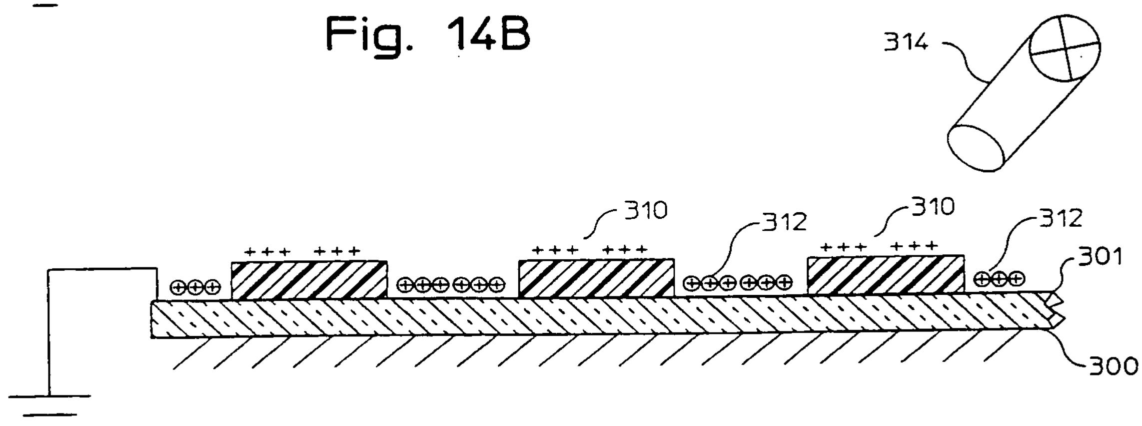

Fig. 14C

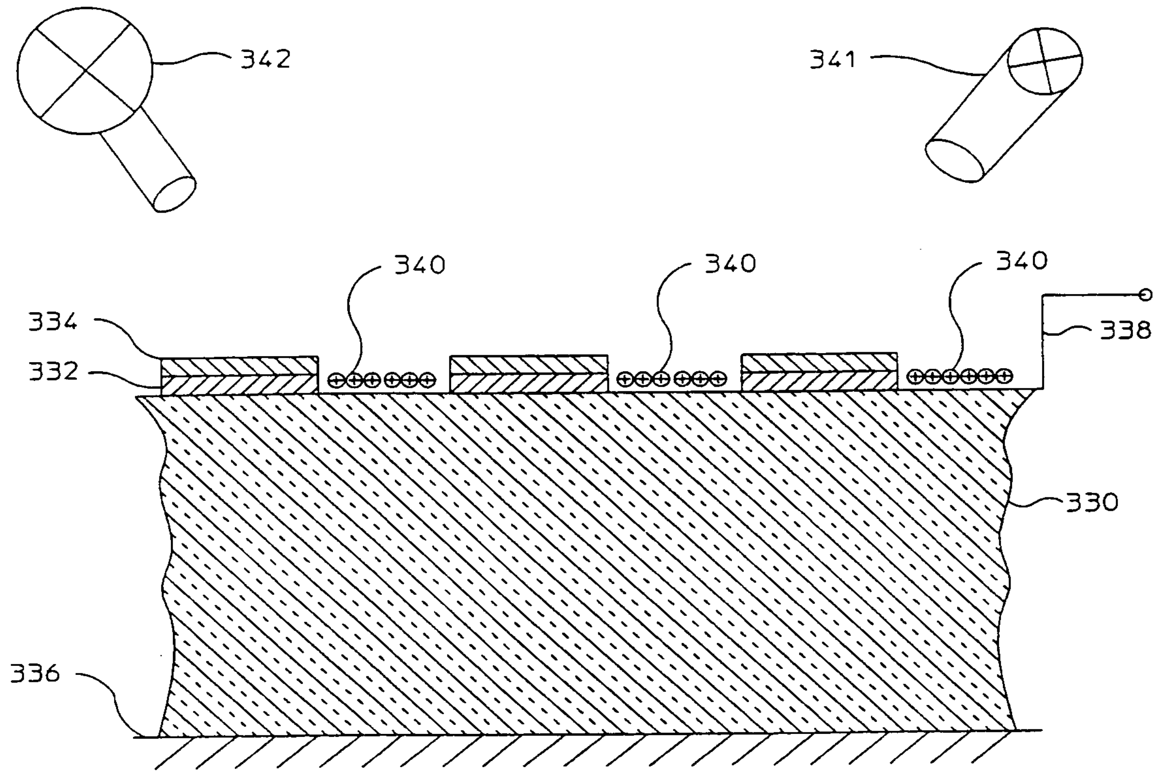

Fig. 14D